

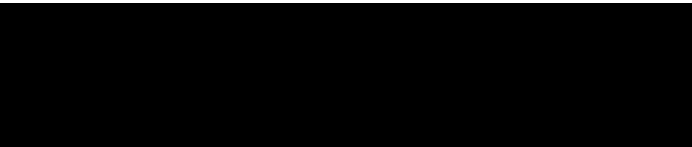
Table of Contents

Section 01400 - Quality Requirements

Section 02406 - Tunnel Excavation By TBM

Section 02413 - Tunnel Boring Machine

Section 02430 - Tunnel Grouting



Section 03345 - Concrete Finishing

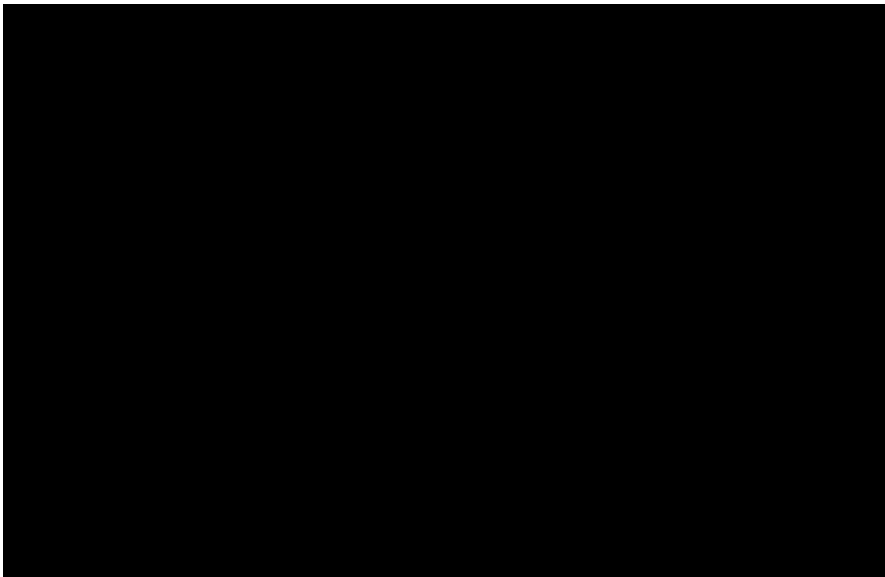
Section 03353 - Sandblasted Concrete Finish

Section 03360 - Architectural Concrete

Section 03370 - Shotcrete

Section 03450 - Pre-Cast Architectural Concrete Stair Units

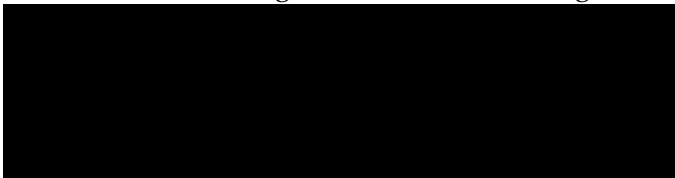
Section 04220 - Architectural Concrete Unit Masonry



Section 09305 - Platform Edge

Section 09310 - Tiling

Section 09962 - High Performance Coating



SECTION 01400
QUALITY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

1.1.1 This Section includes administrative and procedural requirements for quality assurance and quality control for transit facilities.

1.1.2 Refer to Article 10 [Architecture] of Part 2 of this Schedule for additional information and design requirements with regards to the various Minimum Requirements for Construction Specification sections.

1.1.3 Notwithstanding the Minimum Requirements for Construction Specifications identified in this Schedule 4, the Primary Contractor shall refer to Schedule 6 [Quality Management] , Schedule 2 [Representatives, Review Procedure and Consent Procedure], Schedule 9 [Performance Mechanism], and Schedule 17 [Records and Reports] of the Project Agreement for further quality control and assurance requirements and procedures.

1.1.4 Testing and inspecting services are required to verify compliance with the Design-Build Requirements specified or indicated. These services do not relieve the Primary Contractor of responsibility for compliance with the Design-Build Requirements.

1.1.4.1 Specific quality-assurance and -control requirements for individual transit facility construction activities are specified in the sections that specify those activities. Requirements in those sections may also cover production of standard products.

1.1.4.2 Specified tests, inspections, and related actions do not limit the Primary Contractor's other quality-assurance and -control procedures that facilitate compliance with the Design-Build Requirements.

1.1.4.3 Requirements for the Primary Contractor to provide quality-assurance and -control services required by the Province's Representative or authorities having jurisdiction (AHJ) are not limited by provisions of this Section.

1.1.5 Related Sections include the following:

1.1.5.1 Divisions 2 through 16 Sections of this document for specific test and inspection requirements.

1.2 DEFINITIONS

1.2.1 Mockups: Full-size, physical assemblies that are constructed on-site or off site. Mockups are used to verify selections made under sample submittals, to demonstrate aesthetic effects and, where indicated, qualities of materials and execution, and to review construction, coordination, testing, or operation; they are not Samples. Approved mockups establish the standard by which the Work will be judged.

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- 1.2.2 Laboratory mockups: Full-size, physical assemblies that are constructed at a nationally recognized certified independent testing facility to verify performance characteristics.
- 1.2.3 Preconstruction testing: Tests and inspections that are performed specifically for the Project before products and materials are incorporated into the Work to verify performance or compliance with specified criteria.
- 1.2.4 Product testing: Tests and inspections that are performed by a nationally recognized certified independent testing laboratory, or a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with industry standards.
- 1.2.5 Source quality-control testing: Tests and inspections that are performed at the source, i.e., plant, mill, factory, or shop.
- 1.2.6 Field quality-control testing: Tests and inspections that are performed on Site for installation of the Work and for completed Work.
- 1.2.7 Testing agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.
- 1.2.8 Installer/applicator/erector: Contractor or another entity engaged by the Primary Contractor as a Subcontractor to perform a particular construction operation, including installation, erection, application, and similar operations.
- 1.2.9 Experienced: When used with an entity, "experienced" means having successfully completed a minimum of five previous tasks similar in size and scope to these requirements; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

1.3 CONFLICTING REQUIREMENTS

- 1.3.1 General: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, the Primary Contractor shall comply with the most stringent requirement.
- 1.3.2 Minimum quantity or quality levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements.

1.4 SUBMITTALS

- 1.4.1 The Primary Contractor shall refer to the requirements set out in Schedule 6 [Quality Management] and each Section of the Minimum Considerations for Construction Specifications for specific minimum submittal requirements.

- 1.5 QUALITY ASSURANCE
- 1.5.1 General: qualifications paragraphs in this Article establish the minimum qualification levels required; individual specification sections specify additional requirements.
- 1.5.2 Installer qualifications: A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this project, whose work has resulted in construction with a record of successful in-service performance.
- 1.5.3 Manufacturer qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- 1.5.4 Fabricator qualifications: A firm experienced in producing products similar to those indicated for this project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units on schedule.
- 1.5.5 Specialists: Certain sections of the Minimum Standards for Construction Specifications require that specific construction activities shall be performed by entities who are recognized experts in those operations. Specialists shall satisfy qualification requirements indicated and shall be engaged for the activities indicated.
- 1.5.5.1 Requirement for specialists shall not supersede building codes and regulations governing the Work.
- 1.5.6 Testing agency qualifications: An agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ISO/IEC 17025; and with additional qualifications specified in individual sections; and where required by the AHJ, that is acceptable to authorities.
- 1.5.7 Factory-authorized service representative qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products and certify their installation or application meets all manufacturers requirements and specifications that are similar in material, design, and extent to those indicated for this Project to ensure all manufacturers quality and performance criteria will be provided and all guarantees and warranties remain intact and fully enforceable.
- 1.5.8 Preconstruction testing: Where a testing agency is required to perform preconstruction testing for compliance with specified requirements for performance and test methods, these shall comply with the following:
- 1.5.8.1 Primary Contractor responsibilities include the following:
- 1.5.8.1.1 Provide test specimens representative of proposed products and construction.
- 1.5.8.1.2 Submit specimens in a timely manner with sufficient time for testing and analyzing results to prevent delaying the Work.

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- 1.5.8.1.3 Provide sizes and configurations of test assemblies, mockups, and laboratory mockups to adequately demonstrate capability of products to comply with performance requirements.
- 1.5.8.1.4 Build site-assembled test assemblies and mockups using installers who will perform the same tasks for construction of the transit facilities.
- 1.5.8.1.5 Build laboratory mockups at testing facility using personnel, products, and methods of construction indicated for the completed Work.
- 1.5.8.1.6 When testing is complete, remove test specimens, assemblies, mockups, and laboratory mockups; do not reuse products in construction for the transit facility.
- 1.5.8.2 Testing agency Responsibilities: Submit a certified written report of each test, inspection, and similar quality-assurance service to the QA Inspector, with a copy to the Primary Contractor, a copy to the Field Engineer and a copy to the Province's Representative. Interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from the Contract Documents.
- 1.5.9 All components that are to receive coatings or finishes are to be constructed in their finished condition, representative of the final construction as it will be completed in place.
- 1.5.10 Mockups: Before installing portions of the Work requiring mockups, build mockups for each form of construction and finish required to comply with the following requirements, using materials indicated for the completed work in place. Coordinate, combine and consolidate systems and materials in all other sections to provide the following:
 - 1.5.10.1 Notify the Province's Representative and the Field Engineer 10 days in advance of dates and times when mockups will be constructed.
 - 1.5.10.2 Demonstrate the proposed range of aesthetic effects and workmanship.
 - 1.5.10.3 Obtain Province's Representative and Field Engineer approval of mockups before starting work, fabrication, or construction.
 - 1.5.10.3.1 Allow 10 days for initial review and each re-review of each mockup.
 - 1.5.10.4 Maintain mockups during construction of the transit facilities in an undisturbed condition as a standard for judging the completed Work.
 - 1.5.10.5 Demolish and remove mockups when transit facility construction is complete.
- 1.5.11 Laboratory mockups: Comply with requirements of preconstruction testing and those specified in individual Sections in Divisions 2 through 16 of this document.
- 1.6 QUALITY CONTROL
 - 1.6.1 Tests and inspections of transit facility elements are the Primary Contractor's responsibility. Provide quality-control services specified in the Quality Management Plan and those required by

- authorities having jurisdiction. Perform quality-control services required of the Primary Contractor by authorities having jurisdiction, whether specified or not.
- 1.6.1.1 Engage a qualified testing agency to perform these quality-control services.
 - 1.6.1.2 Notify testing agencies at least hours in advance of time when Work that requires testing or inspecting will be performed.
 - 1.6.1.3 Submit a certified written report, in duplicate, of each quality-control service to the Province's Representative.
 - 1.6.1.4 Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.
- 1.6.2 Manufacturer's field services: Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing as specified in the Quality Management Plan.
- 1.6.3 Testing agency responsibilities: Cooperate with the Province's Representative, the Primary Contractor and the Field Engineer in performance of duties. Provide qualified personnel to perform required tests and inspections.
- 1.6.3.1 Notify the Province's Representative and the Primary Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
 - 1.6.3.2 Determine the location from which test samples will be taken and in which in-situ tests are conducted.
 - 1.6.3.3 Conduct and interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.
- 1.7 SHOP DRAWINGS
- 1.7.1 The Subcontractor will submit the shop drawings to the Primary Contractor. The Primary Contractor will prepare submittal reviews and make all submittal and review records and samples available on request to the Province's Representative for review or audit.
- 1.8 DELIVERY, STORAGE AND HANDLING
- 1.8.1 All products, materials and prefabricated assemblies shall be delivered to the Site in manufacturer's and/or fabricators original protective crating and/or wrappings with labels intact, in a clean and dry condition.
 - 1.8.2 All products, materials and prefabricated assemblies shall be stored on pallets or platforms under waterproof cover, clear of ground contact.
 - 1.8.3 Stacking and handling of all products, materials and prefabricated assemblies shall be in a manner to prevent any damage, deterioration, chipping and cracking of units.

- 1.8.4 All delivery, storage and handling of all products, materials and prefabricated assemblies shall comply with manufacturers and fabricators delivery, storage and handling recommendations and limitations for each product and material.
- 1.8.5 Schedule delivery of all products, materials and prefabricated assemblies to avoid extended on-site storage and to avoid delaying the Work.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 NOT USED

END OF SECTION 01400

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SECTION 02406

TUNNEL EXCAVATION BY TBM

PART 1 – GENERAL

1.01 SECTION INCLUDES

- A. Requirements for furnishing all design, labor, materials, tools, and equipment, and performing all operations necessary for excavating the Bored Tunnel utilizing a Tunnel Boring Machine (TBM), and the installation of permanent support utilizing a precast concrete segmented lining.
- B. Furnishing and installing one-pass permanent tunnel support consisting of bolted and gasketed precast concrete segments. The concrete segments are referred to herein after as the “lining” or “liner”.
- C. Furnishing and placing backfill grout behind precast concrete linings to fill the annular space between lining extrados and excavated surface.
- D. Installing and maintaining temporary drainage and ventilation in the excavations.
- E. Requirements for the TBM for use in excavation of the Bored Tunnels are specified elsewhere.

1.02 SUBMITTALS FOR REVIEW

- A. Resumes of key tunnelling staff as specified. Submit resume's of the Tunnel Design Manager prior to start of Tunnel Design and that of tunnel construction staff (TBM superintendent, TBM operators and hyperbaric consultant) at least 60 days prior to start of Bored Tunnel construction.
- B. Resumes of safety supervisor and safety representative at least 60 days prior to start of construction.
- C. At least 60 days before commencing Bored Tunnel excavation, submit or resubmit the following:
 - 1. Detailed working drawings of excavation sequence, a schedule of operations and methods of construction, including sequence and methods for mobilizing TBM to assembly area, launching TBM, partial or complete disassembly and re-launching TBM for second Bored Tunnel drive. Include a description of any ground treatment carried out at the portals to enable launch and reception of the TBM.
 - 2. For the precast segment lining, details of maintaining circularity and stability of the initial start-up rings, confining the backfill grout and ring build measures to be taken while the TBM advances sufficiently to reach normal production mode. Ring build measures shall meet the tolerances described herein.

3. A Tunnel Safety Plan that meets all Federal and Provincial regulations. Include the following as a minimum:
 - a.) A description of all safety personnel, the chain of responsibility, and the procedure for correcting safety deficiencies.
 - b.) A description of all training provided to workers including initial training, tool box meetings, and special work safety meetings.
 - c.) A description of emergency procedures including egress of workers during fire and smoke incidents.
 - d.) Detailed descriptions including drawings and method statements of the health and safety equipment installations including those required for air quality monitoring, fire protection, gas detection, procedures for calibration and operation and certifications from manufacturers that equipment meets applicable regulatory requirements.
 - e.) A detailed hyperbaric safety plan prepared by the Primary Contractor's hyperbaric consultant, if required, to include the following;
 - a. Part 1: Requirements for compressed air work below 3.5 bar.
 - b. Part 2: Requirements for compressed air work above 3.5 bar. Part 2 to be used to obtain a variance from WorkSafeBC in accordance with CAN/CSA-Z275.3-09. Be responsible for obtaining a temporary variance to CAN/CSA-Z275.3-09 for workers exposed to compressed air pressures in excess of 3.5 bar. Submittal review period does not include the time required to obtain the variance.
 - c. Plant and equipment for the supply and use of compressed air and mixed gas, including but not limited to, generator, stand-by equipment, air flow system control, air locks, medical locks, lighting, decompression chamber, and ventilation.
 - d. Details of supervision, personnel entry, decompression, safety, and emergency procedures specific to work in compressed air.
 - e. Coordination with the Primary Contractor's Health and Safety Program.
4. A work plan covering access to the tunnel face or to the earth pressure or slurry pressure plenum to perform maintenance on the TBM cutterhead or remove obstructions. This shall include, but not be limited to, methods to limit ground losses and safety procedures and a description of any ground improvement that may be carried out. If compressed air methods are required, provide a detailed plan, including air locks, compressors, hyperbaric supervisor, and all relevant safety plans.
5. A work plan for support of the tunnel face due to unplanned stoppages and planned weekends and holidays, or in the event of loss of pressure during tunnelling or during periods of no work such as over a weekend. Also explain TBM start up procedure after shutdown with specific description of procedure to prevent loss of face and ground loss; planned

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machine maintenance schedule, tunnel supply operations, shut-down procedures and any other planned measures.

6. Proposed method of calculating and measuring the face pressure required to maintain face stability and the logic and integrated computer systems that will be used to change the pressure as a function of tunnel depth, ground water level, surface settlement, ground conditions encountered at the face and superimposed static loads. Face pressure calculations shall be summarized for each type of ground condition and transition zone to be encountered by the TBM.
7. A Plan for Tunnel Advance (PFTA) that will address the following in drawing form:
 - Interpreted geology as a developed section including relevant boreholes and tunnel horizon
 - Location plan indicating tunnel, buildings, major utilities and instrumentation
 - Location of any 'sensitive' structures or important features and specific trigger levels.
 - Target face support pressure, and acceptable range of deviation
 - Position of water table or anticipated water pressure
 - Compressed air pressure required for intervention
 - Minimum and maximum grouting pressures
 - Minimum grouting volumes
 - Anticipated thrust / torque values.
 - Location(s) of any ground treatment
 - Postulated ground conditioning
 - Anticipated weight of spoil per increment of advance
8. A work plan for measuring excavated volumes in comparison to shield advance and detecting existence of possible excavation created voids in the ground above the crown or to the sides of the tunnel and a method for filling any voids created by the tunnelling operation. Include a Settlement Control Plan to provide a description of all measures designed to control ground loss and surface settlement, including:
 - a.) All TBM operations designed to minimize ground loss, including control of face pressures, annular grouting and TBM guidance.
 - b.) Action and ultimate limits for all instrumentation, and coordination with the Contingency Plan on how contingency methods will be employed.
9. For a Slurry TBM, include in the work plan, a summary of the slurry treatment plant, treatment plant operations, disposal of slurry, use in the tunnel and potential modifications relative to anticipated ground conditions.
10. For an EPB TBM include in the work plan, details of the types of conditioners to be used, and a summary of the production and use of

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conditioners. Provide an overview of how soil conditioners will be selected to deal with the anticipated ground conditions.

- i. Develop a conditioner-testing program to test the effects of proposed conditioners on deposits as described the Geotechnical Design Report(s), the Disclosed Data and as determined by the Primary Contractor, during excavation to reduce stickiness, lumping, balling and abrasion. Adjust conditioners to optimize mining progress and transport of tunnel spoil.
 - ii. Provide product descriptions, dilution ratio, injection ratio, expansion ratio for foams and other soil conditioners for ground conditions described in the Geotechnical Design Report(s), the Disclosed Data and as determined by the Primary Contractor.
11. Detailed description of proposed TBM guidance system including how the control is brought underground, how it is used by the TBM operator to monitor machine performance, how it interfaces with TBM operational systems (jack pressures and extensions, cutterhead and tailskin extensions and articulation) and lining placement and grouting sequence to minimize deviations from the theoretical tunnel alignment and how it will be used to correct misalignment.
12. Detailed description of the shield gap injection system and backfill grouting systems. The backfill grouting system description shall demonstrate that it provides the required strength, deformation and set-up time characteristics to prevent floatation of the lining or any other measures to prevent same, and including a description of the grouting system to demonstrate the capability of complete, immediate, and uniform filling of the tail void as the TBM advances, and how grout set time is designed to ensure consistency with the planned rates of advance of the TBM. Describe method of measuring grout volumes and logic used to determine grout composition and pressures as a function of tunnel depth, ground, and groundwater conditions, and describe interlock system to prevent shield advance without tail void grouting.
13. A work plan for rectifying water leakage into the finished tunnel.
14. Segment erection plan, including:
 - a.) Transport of segments into the tunnel and the face
 - b.) Method of gripping segment
 - c.) Control of segment erection to limit damage, lipping or other quality problems.
 - d.) Coordination between the segment erector and the main propulsion jacks.
 - e.) Methods to assure that gaskets are not damaged and permanently compressed
 - f.) Methods of installing dowels and bolts, and of tightening bolts
 - g.) Systems for controlling and reporting ring build.

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15. Muck Disposal Plan – Provide a description of how muck will be transported and disposed of off site. Include documentation that the disposal meets all Federal and Provincial requirements. Provide details on how truck traffic will be controlled to minimize impacts on surrounding businesses and residences.

D. Contingency Plans:

1. Measures to be implemented if commercial electric power to TBM and support system is interrupted.
2. Measures to be implemented for high groundwater or utility inflows.
3. Measures to correct deviations from design line and grade.
4. Corrective actions to be utilized for each Action Level associated with surface settlement and groundwater monitoring.

- E. Tunnelling Quality Plan: Include all required certifications and qualification documents including a detailed plan of the site organization and responsibilities of all planned personnel.

1.03 SUBMITTALS FOR REVIEW

- A. While tunnel excavation is in progress, submit to the Province's Representative a daily record showing line and grade of centerline of tunnel at the invert relative to the theoretical alignment. The record shall be based on records from the TBM guidance system, supported by as-built survey described herein.
- B. Submit weekly the results of as-built line and grade survey results. Also submit tunnel cross sections showing the actual tunnel lining cross-sections compared to the theoretical cross-sections. Submit cross sections only after deformation of the ring has stabilized. The as built cross section shall comply with the construction tolerances.
- C. Submit the line and grade TBM guidance system information, both in hard copy and in electronic form. The hard copy shall show the current data, while the electronic file shall contain both the current and historic data. The initial submittal shall also detail the Primary Contractor's complete procedures on the operation of the guidance system, frequency of setups on tangents and in curves, bringing the line and grade into the tunnel and independent verification measures to check the accuracy of the surveys.
- D. Within 60 days of completion of excavation of each Bored Tunnel, provide a complete record in electronic form, in tabular form and drawing form, the as-built survey data. Data must be presented in the form of station, offset from the baseline track (as stated in the contract documents, or design centerline for untracked structures) and elevation, and include cross section diagrams that show the variance of the as-built from design with values of maximum

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differentials indicated. Data points and a best-fit surface shall be shown with any anomalies explained. Survey data, including graphical cross sections, shall be presented at regular intervals not to exceed every fifth ring; also at each side of abrupt changes in cross section and at other points. Contour-type diagrams shall be produced as developed plans/sections for the entire surface of each Bored Tunnel indicating deviation from the design (showing extra clearance as positive).

E. Final As-Built Tunnel Survey of Precast Concrete Segment Liner:

1. A tunnel survey shall be conducted upon completion of the precast concrete tunnel lining installation and prior to any subsequent concreting work, to verify final as-built line, level, grade and internal clearances.
2. Fix permanent reference points in the crown of the tunnel at maximum intervals of 60m on straight sections and 30m on curve sections. Such reference points shall be accurately coordinated and shall be installed to not conflict with any part of the permanent structures, and shall be left in place for the following contract.
3. Every fifth ring shall be surveyed at four points. The final as-built survey shall show locations of all reference points and cross passages.
4. The final survey shall be based on one closed traverse for each tunnel.
5. Paper and electronic copies of survey data, calculations and graphical representations showing any deviations against the design alignment shall be submitted to the Province's Representative, in a format acceptable to the Province's Representative. Demonstrate that the as-built tunnel is acceptable for the design track alignment.
6. Identify out-of-tolerance sections and re-survey at closer ring intervals as required to refine limits. Demonstrate that the design track alignment is acceptable for the out-of-tolerance sections. If not acceptable, design and propose modifications that will achieve required vehicle clearance envelope, rail operating parameters and provide required emergency access/egress space. Upon review of proposed modifications by the Province's Representative, perform modifications.

F. Maintain daily summary shift records as excavation progresses and provide one copy of such before 12:00 PM of the following workday. Keep such other records as deemed necessary. The following data shall be included in the daily summary shift record for each tunnel heading:

1. Station of tunnel heading faces at start and end of each work shift.

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2. Ring report detailing type, quantity, and location of precast segments installed.
 3. Any issues related to alignment, problems with segment erection, or damage to segments. Include a description of notification and corrective action for each issue.
 4. Evaluation of any in-tunnel monitoring results.
 5. Number of workers employed per shift for each workday categorized by union trade, idle equipment, active equipment, and site visitors.
 6. General geotechnical conditions as noted by TBM operator or others.
 7. Air quality and gas monitoring data.
- G. Detailed TBM Reports on TBM tunnel excavation and performance data shall be prepared commencing on the first day of TBM assembly and cover a continuous period until the TBM is removed from the Bored Tunnels. One hard copy of the detailed shift reports, signed by the Primary Contractor's representative, and one electronic copy shall be provided to the Province's Representative on a weekly basis. Data collection shall be accomplished by integrating TBM utilization and TBM downtime based on both electronic and manual recording systems. The following TBM downtime classes (generally recorded manually) are the minimum required:
1. TBM cutter changes, cutterhead check, all operating systems, and general or corrective maintenance
 2. Backup system; power supply, air/water/electric extensions, ventilation system, trailing conveyor, continuous conveyor, train delay for spoil removal, train delay for supplies, shaft delays (crane, conveyors), laying rails, derailments, clearance through curves
 3. Ground Conditions; segment ring build or installation, probing, ground treatment from within the tunnel, groundwater inflow, gas inflow
- H. On a monthly basis, submit a TBM Report, in the form of an organized table, in both hardcopy and electronic form. The report shall contain the following as a minimum:
1. Progress for the month, including start and finish of the running tunnels, and progress on the cross passages.
 2. Cutter changes, including time, date, TBM clock time, station, cutter type (e.g., constant section) and reason for replacement along with cutter position or number. The report shall also clearly indicate whether a cutter replacement is with a used hub/ new ring, new hub/new ring, new hub/used ring, and changes in ring metallurgy or ring type/geometry (e.g., constant section). A plan of the cutter position on the TBM cutterhead face shall be provided. The plan shall also report the cutter position radial distance from the origin center.
 3. Segment ring erection including any quality issues affecting the lining.

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4. Any down time, organized by reasons for the down time.
 5. The electronic table version shall be compatible with and easily imported to both Microsoft Access and Excel. A selected version of Access and Excel shall be proposed to and approved by the Province's Representative. A proposed table format shall be submitted to the Province's Representative for review and approval.
- I. For the precast concrete segment liner include lining ring data, on a weekly basis in a format acceptable to the Province's Representative the following:
1. Quality records of manufactured segments.
 2. Quality records of segments delivered to the work site consisting of bills of lading (shipping statements).
 3. Time of erection starts and finishes
 4. Prepare, maintain, and provide the following records after each shift for each erected ring. Include identification of each segment and ring as applicable:
 - a.) Summary of all data automatically recorded by the TBM guidance, alignment control, and TBM monitoring system.
 - b.) Orientation of lining ring (position of key segment).
 - c.) Grout pressures and quantities (backfill and check grout).
 - d.) Measurements of horizontal and vertical diameters for each tunnel support ring at the completion of each ring. Complete records of measurements, with records of grouting for each ring.
 - e.) Delays during ring build.
 - f.) Damages and repair or replacement to lining segments or gaskets during ring build or after start of shoving for the next ring.
 - g.) Position, dimension, description, cause and correction of such damage of liner or gasket.
 - h.) Changes to means or methods to prevent recurrence of damage.
 - i.) Packing and shim materials, dimensions and locations.
 - j.) Location of eight points around circumference presented as coordinates (station, offset and elevations) relative to the design track alignment, and diametric dimension between opposing points. The points surveyed shall be one in the crown, one in the invert, one at each horizontal axis and one at each end of the diagonals at 45 degrees to the vertical axis. All measurements shall be taken on the leading edge of the ring and at the inside face of the linings. The tunnel centerline shall be calculated from the surveyed points and presented as coordinates (station, offset, Eastings, Northings, and elevation).
 - k.) Maximum size of steps at each radial joint.
 - l.) Maximum size of steps at each circumferential joint with arc length for any step exceeding 5mm.

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- m.) Deviation of the crown dowel hole from the tunnel centerline, to nearest 3mm.
 - n.) Position and description of any other damage and/or water leakage.
 - o.) Date and shift built.
 - 5. Non-conformance reports including:
 - a.) Out-of-tolerance tunnel lining ring installation.
 - b.) Segments or rings that are found to be damaged after erection.
 - 6. Shift report deliverables.
 - 7. Location, time, and results of ring planarity checks conducted during the work shift.
- J. Submit additional reports on a weekly basis as follows:
- 1. For the precast segments, records of ring deformation, damages for each ring lining element including repairs affected, leakage inflows, etc. The damages shall include the length and depth of each crack or spall.
 - 2. Results of strength tests for the injected tail void (backfill) grout when using precast segments and initial readings.
 - 3. The quantity and location of all instrumentation installed during the shift.
 - 4. Cross sections of the tunnel showing the as built liner dimensions with respect to the required dynamic train envelope and allowable construction tolerances. The cross sections shall be supported by the diametric measurements required herein. The measurement data shall be submitted in an organized manner to the satisfaction of the Province's Representative. Submit a proposed format for the cross section and supporting data a minimum of 30 days before the initiation of tunnelling.
- K. To comply with all applicable health and safety reporting requirements, provide reports as and when required by public authorities, and provide a copy of each such report prepared to the Province's Representative at the same time that each is sent to the appropriate public authorities and, in all cases, within 24 hours following preparation of each report.

PART 3 - EXECUTION

3.01 GENERAL:

- A. Pre-Tunnelling Meeting to be held not less than 30 calendar days prior to TBM launch, and to be attended by both the Primary Contractor and Province's Representative.

3.02 EXCAVATION:

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- A. Excavation shall be to the lines, grades, and dimensions shown on the Primary Contractor's Design drawings and as specified. Methods shall be used and precautions shall be taken to minimize removal, loosening, and ravelling of material beyond the minimum excavation necessary to satisfy all criteria.
- B. Continually monitor line and grade as the excavations advance. Line and grade deviation shall not exceed 75 mm from design line and grade. If deviation exceeds an action limit of 40 mm, immediately implement contingency plans to bring the excavation back to the design line and grade. Immediately notify the Province's Representative if the action limit is exceeded and stop work as directed, or as necessary, to implement the contingency plan.
- C. Do not advance the TBM at any time when the TBM guidance or TBM electronic monitoring systems are out of order.
- D. Validate line and grade continually with survey control being undertaken by qualified survey personnel.

3.03 INSTALLATION OF PRECAST CONCRETE SEGMENT LINER:

- B. Use only methods of lining erection which have been certified in writing by both the TBM and the segment manufacturer and which have been reviewed and approved by the Province's Representative.
- C. Installation tolerances:
 - 1. Projection or lipping of a segment with respect to the adjoining segment shall not exceed 8 mm on the inside face.
 - 2. The deviation from the true inside diameter of the completed ring shall not exceed plus or minus 0.50%
 - 3. The internal surface of the lining shall not deviate from its design position by more than the total construction tolerance shown on the drawings.
 - 4. The roll of each ring in relation to the previous ring shall be no greater than can be accommodated within the limitations of bolt hole and dowel clearances.
- D. A non-conformance report shall be submitted immediately for any ring that is found to be out-of-tolerance.
- E. Out-of-Tolerance Installed Lining:
 - 1. The tolerance shall include impacts from both line and grade deviation and diametric deviation.

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2. Implement immediate remedial actions to bring the tunnel drive and tunnel lining into tolerance. The Primary Contractor shall stop work if:
 - a.) The tunnel drive and lining is out-of-tolerance and no satisfactory remedial action is proposed or
 - b.) The remedial action is not implemented in a timely manner or is not effective.
 3. Segment grinding is not permitted.
- F. Inspect concrete segments, joint connection assemblies, joint packings and gaskets before being taken underground and just before erection. Bring imperfections and damage to the attention of the Province's Representative; repair or replace as required.
 - G. Each time a segment is placed, any correction required because of the tunnel alignment and build checks, shall be carried out before the segment bolts are tightened and the thrust rams put back onto the segments. Segment bolts, dowels and thrust rams shall be used to provide compression of the gaskets and compression packing and maintain optimum joint closure tolerances during erection of subsequent rings. Fully tighten bolts in every bolt hole and fully compress dowels in every dowel hole.
 - H. Radial joints in adjacent rings shall be arranged so that there are no continuous radial joints.
 - I. At all times during the ring building process, great care shall be taken to avoid causing damage to the tunnel segments, and gaskets. Lubricate gasket using a product recommended by the gasket manufacturer. After the completion of the building process, the integrity of every ring and all visible gaskets shall be checked before the next advance begins.
 - J. Should any new cracks or concrete defects occur in the erected tunnel lining, or an existing crack or defect becomes enlarged, then immediately review the following with the Province's Representative:
 1. Lining erection details
 2. Grout records.
 3. Thrust records and thrust ram selection.
 4. TBM operational parameters and any proposed changes to Work Plans.
 - K. Backfill Grouting:
 1. The annulus between the segmental lining and the excavated surface shall be grouted continuously and simultaneously as the TBM progresses. Grouting through grout holes in segments will not be accepted as the primary method of backfill grouting

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2. Adjust grout set-up times for compatibility with machine progress rates and planned or unplanned work stoppages.
3. As the segment ring is pushed in place, continuously pump grout at sufficient pressure and in sufficient volume to ensure complete and total filling of the annular void and to support the surrounding ground.
4. Grout pressures shall be controlled to prevent damage to the tunnel lining, and ground deformation exceeding allowable limits.
5. If buoyancy of the tunnel lining in the annular grout causes damage, distortions or excessive vertical movement, remedial measures and adjustments in grout mixes and injection procedures shall be proposed for review by the Province's Representative.
6. Immediately stop the TBM and secure the tunnel when the automatic backfill grouting system fails or is not functioning correctly. Do not resume advancing the TBM until the automatic backfill grouting system is functioning correctly.

L. Finishing of Installed Tunnel Lining

1. Temporary Holes Drilled into the Lining: Clean and fill with mortar after final tunnel grouting. Trowel mortar into place and pack to produce a dense mortar.
2. Cast bolt pockets and grout holes shall not be filled with mortar. Leave cast grout holes in a condition as specified herein.
3. Upon completion of the Work, clean tunnels to remove any water, debris, sediment, oil or any other contaminant.

M. Watertightness (Completed Tunnels)

- a.) Where water leakage rates into the tunnel exceed the specified limits, the Primary Contractor may propose means to rectify this to stop leakage for review by the Province's Representative. Undertake any required remedial measures as reviewed by the Province's Representative. There is no separate payment for grouting of the soil to achieve water tightness of the completed segment rings; grouting is incidental to the work.
- b.) Establish grout injection pressures for sealing leaks by means of an on site demonstration. Do not damage the lining.

N. Maintaining Pillar Stability: The Primary Contractor shall analyze the soil pillar between bored tunnels for TBM forces applied by the subsequent TBM boring operations and install appropriate

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reinforcement and/or bracing as required to maintain pillar stability during the adjacent tunnelling operation.

O. Surveying and Alignment Control:

1. Surveying to be in accordance with current accepted state-of-the art industry standard conventional underground surveying practice.
2. For the precast concrete segment liner survey work during tunnelling and segment erection shall be as specified herein:
 - a.) Assure that the TBM guidance system provides an accurate record of the line and grade of the tunnel including corrections made by the TBM operator.
 - b.) Measure as-built cross section of the tunnel to assure that the design dynamic envelope will fit with an adequate buffer. Consider deformation of the segments to ground loading as part of the as-built determination.
 - c.) Advance and verify all underground tunnel control as needed.

SECTION 02413
(EXECUTION)

TUNNEL BORING MACHINE

DESCRIPTION

- This Section specifies requirements for the Tunnel Boring Machine (TBM) to be used for the excavation of the Evergreen Line Bored Tunnels.

PRODUCTS

DEFINITIONS

- Tunnel Boring Machine (TBM) – A tunneling machine which will provide full excavation face support with excavated soil modified with conditioning agents and completely filling the working chamber, under pressure generally using either a Slurry TBM or an Earth Pressure Balance (EPB) TBM, includes the entire system of tunnel boring equipment which includes auxiliary and support equipment comprising the TBM, backup gear and all equipment and materials affixed thereto.
- Earth Pressure Balance (EPB) TBM – A TBM with a pressure bulkhead located behind the face to form a plenum mixing chamber under pressure. Pressure is regulated by a combination of advance rate, thrust, screw conveyor, and fluid injection. Liquids, foams and other types of soil conditioners are injected at the cutterhead face and into the plenum and screw conveyor to be mixed with material excavated by the rotary cutterhead. The mix is extracted by means of a screw conveyor in an operation integrated with the TBM advance.
- Slurry TBM – A TBM with a pressure bulkhead located behind the face to form a plenum under pressure. Bentonite slurry or other liquid medium is introduced into the plenum chamber under a controlled pressure. The support fluid is injected out into the ground at the face to form a semi-impermeable membrane at the face, which transfers the support pressure from the plenum chamber into the ground to stabilize the face. The support fluid is mixed with material excavated by the rotary cutterhead and the resultant slurry, with cuttings, is removed by pumping.

GENERAL

- A slurry TBM or EPB TBM shall be used to excavate the Evergreen Line Bored Tunnels. The tunnel boring machine systems (including the trailing gear) shall be:
 - new and built for this Project; or
 - subject to the requirements of Article 7.1.3 [Tunnel Boring Machine], Part 2 of Schedule 4, refurbished or rebuilt for this Project.

The TBM and back-up equipment shall be designed to operate in all conditions indicated in the Geotechnical Design Report(s) and the Disclosed Data, and as determined by the Primary Contractor. The Primary Contractor shall implement an organized daily, weekly and monthly TBM inspection and maintenance program.

- Should the Primary Contractor elect to use a refurbished or re-built TBM, then, prior to the proving trials in the original manufacturer's factory to be undertaken pursuant of Article 7.1.3.2(a)(ii)A., Part 2 of Schedule 4, the Primary Contractor shall submit the

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technical specifications for the refurbished TBM and associated systems to the Province's Representative for review under the Review Procedure. The following shall apply:

- Operate TBM to maintain face stability and minimize surface settlements at all times under all conditions during both excavation and periods of TBM shutdown or stoppage, during cutterhead maintenance and including sudden losses of power.
- The diameter of excavated tunnel shall be the minimum overcut as required to produce minimal over-excavation and the least necessary clearance for installation of the permanent segmental lining, trackwork and systems. The TBM and back up equipment shall be designed to negotiate the minimum radii horizontal and vertical curves in the alignment and meet the required alignment tolerances.
- Provide ability for drilling equipment to be mounted in the TBM. Drilling ports equipped with valves shall be incorporated into the TBM shield so that drill casings can be sleeved through glands into ground when drilling ahead of the TBM.

CUTTERHEAD AND TOOLS

- Design and operate TBM to be capable of digesting boulders, as described in the Geotechnical Design Report(s) and the Disclosed Data, and as determined by the Primary Contractor without interruption in mining. The TBM is to include disc cutters on the cutterhead, which in combination with the size of opening in the cutterhead will restrict the size of boulder removal as required by the excavation system; for Slurry TBM, the size that can be dealt with by the crusher; for an EPB TBM machine, the size that can traverse the screw conveyor.
- Provide sufficient face hardening and replaceable wear plating for TBM components subject to wear due to the abrasive soils along the tunnel drive. The front face, gauge and peripheral zones of the cutterhead shall be protected against abrasive wear. The rear section of the cutterhead adjacent to the front shield shall be provided with adequate wear resistant materials. All wear resistant materials shall be a minimum hardness of 60Rc. and of a thickness that shall maintain the cutter head in good working order for the complete tunnel drives.
- Design the cutterhead to permit the use of both disc cutters and ripper type cutters which can be replaced from the excavation chamber (back loading). Disc and ripper type cutters shall be interchangeable with each other. Incorporate adjustable gauge cutters.
- Cutting tool spacing shall be sufficient to permit efficient excavation of the material at the tunnel face with sufficient tool gap and penetration for disc cutters.
- The Primary Contractor shall carry out regular face inspections to check for cutterhead wear.
- Equip the TBM with pressure cells in the cutterhead chamber. Pressure cells are to be located at the invert, springline (or axis) and at the crown in sufficient number to ensure continued readings in the event of loss of an individual pressure cell. In addition, for an EPB TBM, provide pressure cells along the screw conveyor.
- For EPB TBM, provide and use conditioners required to stabilize the face under all conditions described in the Geotechnical Design Report(s) and the Disclosed Data, and as determined by the Primary Contractor. Soil conditioners shall be used to stabilize the face, reduce cutterhead and screw conveyor torque demand, reduce tool and cutterhead wear, prevent adhesion and clogging, and to develop a soil plug and

maintain a positive pressure in the working chamber, and for uniform pressure drop along the screw conveyor, and to condition the tunnel spoil for ease of handling at the heading.

- For EPB TBM, locate ports for injection on the cutterhead, in the plenum chamber and in the screw conveyor such that the excavated soil can be modified at the face in the cutting head, forward chamber and screw conveyor housing.
- A bentonite injection system shall be provided for EPB TBM. The injection system shall incorporate mixing and storage tank(s). The bentonite system shall be arranged as a secondary face support system such that it automatically pumps bentonite slurry into the cutter head pressure chamber when pressure at the tunnel face drops below the agreed minimum target face pressure. The bentonite system is to be maintained under pressure at all times when TBM is operating under pressure. Refill cutterhead and mixing chamber/plenum prior to restart of mining after cutterhead maintenance or cutter change.
- A cutterhead wear detecting system shall be provided to cutting tools, muck collecting buckets and the main cutter head structure which shall indicate when the wear has reached unacceptable levels. This system shall utilise either high pressure oil (up to 350 bar) or suitably robust electrical sensors and have sufficient locations around the cutterhead to provide adequate indication of wear and the need for specific remedial intervention for repair. A minimum of six wear detectors shall be provided.

CUTTERHEAD DRIVE SYSTEM AND MAIN BEARING:

- Provide the TBM with adequate torque and power to the cutterhead so that the machine is not torque limited while operating under any of the ground conditions indicated. Provide a reversible, cutterhead drive system capable of starting at maximum torque.
- Provide certification from the main bearing manufacturer that the bearing is suitable for the loads calculated by the TBM manufacturer based upon the ground conditions indicated and that the main bearing shall have a minimum bearing life of at least 10,000 operational hours.
- Provide oil lubricated main bearing with pumping and filtration circuits equipped with accessible sampling points.
- The main bearing shall be new and replaceable from within the tunnel.

SHIELD AND SEALS

- The shield shall be designed to withstand the maximum loads which can be induced from operation of the TBM together with the overburden load.
- Provide and use main bearing seals designed for maximum expected pressure (with appropriate Factor of Safety) within the excavation chamber from the combined hydrostatic and earth pressure and from the enhanced pressure caused by the action of the shove jacks. Provide an automatic system of main bearing seal lubrication. Equip oil system with monitoring of oil pressure and redundant filters

systems for cleanness to protect the main bearing. Oil and interior seals shall be capable of being changed from inside the TBM.

- Shield tail seals to include a redundant system of wire brushes to seal against maximum hydrostatic and backfill grout pressure. The seals shall be continuously fed with fibrous grease whenever the TBM is moving forward. Tail seals other than the rear seal shall be replaceable from within the tunnel. Incorporate an inflatable safety seal deployable when work is carried out on the brush seals or in an emergency where leakage cannot be controlled by any other means.
- The articulation joint seals shall incorporate the following:
 - Designed to allow adjustment and replacement of the seals from within the shield.
 - Incorporate an inflatable safety seal deployable when work is carried out on the seals or in an emergency where leakage cannot be controlled by any other means.

PROPULSION AND STEERING SYSTEM:

- Design TBM to provide forward thrust by thrust cylinders reacting against the installed segmental liner without damaging or overstressing either the liner or the thrust jacks at any time.
- Provide thrust system that can advance the TBM under maximum combined reaction from earth and hydrostatic pressure, and all other superimposed static and dynamic loads, shield friction, face stabilization load, and disc or any other excavation tools.
- Provide thrust cylinders having individual actuation, synchronized actuation, and individual maximum thrust control. Thrust cylinders shall not permit displacements when idle or shut down for any reason. Provide support of thrust cylinders to prevent jamming in curves and to transmit thrust force perpendicular to the segment face.
- Provide propulsion cylinder extensometers at minimum four positions separated by 90 degrees.
- Provide propulsion cylinder shoes or partial jacking rings as required to distribute thrust loads across the leading edge of the pre-cast segment ring without developing eccentric loading on the segment ring for which the segments were not designed. The propulsion cylinder shall be concentric with segmental ring centerline.

ERECTOR SYSTEM:

- Segments shall be assembled by an erector mechanism into rings under protection of the tail shield in the orientation and to the tolerance specified in Sections 02406 and 3320 without causing damage to the segments or gaskets.
- Erector system shall be compatible with the TBM and precast segmental lining and meet the requirements specified in Section 03320.

- The lifting and gripping mechanism shall be designed to handle all loads with an adequate factor of safety in the axial, radial, and circumferential directions, and in the three articulation angles corresponding to the six degrees of freedom.
- Sufficient rigidity and longitudinal travel to permit installation or removal of a segmental ring located on the wire brush seals.
- Safety devices shall be incorporated to ensure segments cannot be released during handling. In the event of a loss of power, the erector shall permit safe lowering of the segments.
- The segment feeder shall supply the erector with segments at the correct orientation and be capable of reverse operation for the removal of damaged or incorrect segments.
- The segment erector arm shall have sufficient capacity to ensure that the longitudinal joint gaskets are sufficiently compressed.

GROUTING SYSTEM:

- Provide tail void grouting system through the tail shield. Coordinate the shield tail seal and the liner system to ensure a competent seal. Provide a minimum of 4 grouting pipes plus a redundant pipe at each location in the event that the first pipe becomes blocked. Provide means of clearing blocked pipes of grout. Grouting through holes in segments will not be accepted as the primary method of backfill grouting. Drilling through the concrete segment for check grouting, except through lifting holes is not permitted.
- TBM to include a computer operated grouting system which is to be integrated with the real time TBM data management and real time construction monitoring system, which considers the rate of advance, grout quantities, prevailing pressures and other related variables to continuously adjust required volume of grout.
- Provide a lock out device to prohibit TBM advance unless backfill grouting systems are operational and providing the required grout.
 - Equip pumps with water/bentonite connection to facilitate flushing.
 - Drilling equipment and associated staging to enable recovery of tail void grout samples and proof grouting at any position around the ring.

MUCK HANDLING SYSTEM:

- Muck handling components shall be designed for abrasion resistance and durability for the indicated ground conditions. Provide mixing paddles, multiple mixing bars or other means within the muck chamber to condition muck uniformly. The cutterhead shall have a series of paddles or structural arms protruding from the rear face of the cutterhead and from the front face of the shield bulkhead that are designed and located to prevent excavated material plugging within the excavation chamber. The mixing arms/paddles shall be rigid heavy structures designed to withstand any impact loading and shaped to improve flow through the excavated material. The arms/paddles shall be heavily protected from abrasion with suitable hard faced welding materials.

- If a continuous conveyor is used; provide a twin belt scale weighing system connected to the TBM PLC with values continuously displayed at the operator position. Non-weighing nuclear density sensors are not acceptable substitutes for scales.
- For EPB TBM
 - Operate TBM at all times with a screw conveyor to control the pressure at the face and to remove muck from the cutterhead chamber.
 - Provide a reversible screw conveyor that includes primary and secondary sections. Each section to be equipped with a dedicated drive and separated with a guillotine gate. Provide the capability for the automatic charging and releasing of excavated material from the secondary screw which will permit the controlled excavation of non-cohesive materials under the ground water pressure indicated.
 - Locate the screw conveyor inlet near the bottom of the Excavation Chamber. Bulkhead doors to be provided at the inlet which are to be designed to isolate the screw conveyor from the Excavation Chamber.
 - The screw outlet shall be fitted with a guillotine gate designed to operate and seal maximum hydrostatic and earth pressure in all soil types indicated.
 - Equip the screw conveyor sleeve with a minimum of two pressure sensors one located near the inlet and the other near the outlet.
 - The screw conveyor shall be provided with a telescopic facility to withdraw it from the pressure bulkhead. Hydraulic closure gate(s) shall be provided to seal the aperture of the screw conveyor at the pressure bulkhead when the screw has been withdrawn. A suitable blanking flange shall be provided to the screw casing when the screw conveyor has been removed for any reason. The telescopic facility, hydraulic closure gate and blanking flange shall be designed such that the screw conveyor can be removed and replaced while maintaining the target face pressure in the excavation chamber at all times. Ports shall be provided in the screw conveyor casing to allow inspection of the flights of the screw conveyor without the need to withdraw it from the casing.
 - Provide the TBM with the state of the art weight/volume monitoring devices, linked to the TBM data management system, to provide accurate determination and reporting of the excavated volume in a real time basis. The monitoring system shall be designed and operated to provide continuous information on the ratio of the actual to theoretical measurement of the material excavated throughout each advance, after allowing for the volume of conditioner injected. Each belt conveyor shall be provided with at least two belt weighting devices (for cross-checking) as part of an automatic monitoring system for the material discharge per ring of advance. Details of the proposed system and the accuracy of its measurements shall be submitted to the Province's Representative.
 - Design the screw conveyor for operation in abrasive ground conditions and for efficient replacement from within the tunnel. Primary belt conveyor or any other feeding except from the screw conveyor from the cutter head chamber will not be acceptable.
 - As part of the systems to control face pressure, the screw conveyor must be designed to maintain the required face pressure within the cutterhead chamber and the entrance to the screw conveyor. The pressure shall reduce along the screw

conveyor such that atmospheric pressures are achieved at the screw exit by proper ground conditioning, control of the screw conveyor and the pressure lock out device. Operation of the TBM in “open or unpressurized mode” is not permitted at any time.

- The Ground Conditioning System shall be sized and configured as required to form a homogeneous conditioned soil suitable for control of required support pressure for all ground conditions. The system shall be computer controlled with interactive parameter setting at the operator position.
- Accumulator with automatic valve which will close the screw guillotine in the event of a power failure.
- Muck handling system to have provisions for sampling.
- For slurry TBM:
 - Design the complete slurry system and conditioners required to stabilize the face and drive the tunnel, to work under all conditions described in the Geotechnical Design Report(s) and the Disclosed Data, and as determined by the Primary Contractor. This includes the complete slurry system and conditioners required to stabilize the face and drive the tunnel.
 - Provide a quality control testing program for slurry including a description of required tests and range of values considered acceptable for ground conditions anticipated for each tested parameter.
 - Design the slurry treatment plant to remove the solids from suspension at a sufficient rate so that slurry treatment does not limit the TBM advance rate. Address the sustained volume need for sudden loss of slurry supply in voids or gravels. Replace or recondition slurry as needed with fresh slurry and/or conditioners.
 - Provide a means to report the operational status of the slurry plant including key pumps and level indicators and weight of discharged muck.
 - Provide abrasion resistant closed circuit mucking system capable of discharging solids through a slurry discharge line and discharge pumps which is to include:
 - Bypass line and associated valves.
 - Hydraulic accumulators to ensure closure of all bulkhead flanges in case of power loss.
 - Intermediate pumps along the tunnel alignment shall be sufficient to provide slurry flow rate and pressure needed for required support pressure and slurry discharge for the anticipated maximum TBM advance rate and tunnel length.
 - A minimum of two abrasion resistant pressure sensors along the slurry charge (feed) line segment and two additional abrasion resistant pressure sensors along the slurry discharge line which can be replaced under operating conditions.
 - Provide ability to increase slurry density to counter slurry loss and to prevent face collapses.

- Provide slurry suspension reserve for use if a sudden, high flow rate slurry loss occurs during tunnelling in highly permeable soils.
- Provide equipment to measure weight of the excavated material at the separation plant:
 - Flow and density meters in the supply and discharge slurry lines.
 - Bentonite slurry recharge flow meter.

TBM GUIDANCE SYSTEM:

- Provide TBM with a computerized laser-theodolite based guidance system. System to be capable of continuously displaying the precise position and orientation of the TBM using a numerical and graphical display of horizontal and vertical deviation from the design tunnel axis and direction with respect to the design tunnel axis.
- Capable of displaying the position and orientation of the erected rings with the horizontal and vertical deviations from the design tunnel axis.
- The system shall be capable of calculating and displaying correction curve data with interactive parameter setting.
- The system shall provide the means to monitor, record, and display the following:
 - Continuous monitoring of the date, time, and tunnel station.
 - Segment ring, design tunnel axis stationing values, as-driven coordinates and elevations, horizontal and vertical offsets from design tunnel axis.
 - The number and orientation of tapered segment rings required to achieve the desired alignment and the location of the axis of each ring relative to the axis of the tail shield.
 - Extensions of propulsion and active/passive articulation cylinders.

TBM DATA ACQUISITION SYSTEM:

- Provide a system for real-time continuous data monitoring and acquisition, storage and display which is to include:
 - Cutterhead rpm, direction and torque.
 - Propulsion cylinder stroke pressure, average instantaneous advance rate and total thrust shall be shown for all cylinders.
 - Extensions of propulsion and active/passive articulation cylinders at a minimum of four positions, pressure and total thrust.
 - Face support pressure and ground conditioning system data including water, polymer and foam solution flows and pressure, air flows and pressure, foam injection ratio and foam expansion ration and foam expansion ratio for each individual line.

- Discharge system from excavation chamber including stone crusher on a slurry TBM and screw conveyor rotation speed and guillotine gate position indication on an EPB TBM.
- Bulkhead valve status for the slurry TBM.
- TBM Guidance System data.
- Electric motor status and power consumption.
- Main bearing and main bearing sealing system oil pressure, temperature and flow. All gases included in the gas detection and monitoring system.
- Pressures and volumes of shield tail grouting and tail seal grease.
- If continuous conveyor is used; provide belt scale weights.
- Record data at maximum time intervals of ten seconds and display in real-time at the TBM operators' position, the Primary Contractor's site office, and the Province's Representative's site office.
- Supply data on a continuous basis for use by the Primary Contractor and the Province's Representative via an automated acquisition system. Store and record data in digital form for later use and retrieval.
- Provide secure Internet-based access to real time and historical data for use by the Province's Representative. Hardware and software shall provide user friendly interface to access all required data.
- In the event of downtime due to hardware within the Primary Contractor's control, notify the Province's Representative of the issue, repair hardware, and restore Internet-based access to real time data within 4 hours of hardware failure. Maintain recording of data at all times.

SPARE PARTS:

- Provide an on-site spare parts inventory as recommended by the TBM manufacturer, which includes the guidance system and data acquisition equipment. Except as noted for main bearing and screw conveyor, replacement parts or maintenance materials are to be stored on or near the Project site and (shall include long lead items including but not limited to:
 - Items listed in the manufacturer's recommended spares list.
 - One complete set of each type of excavation tools (drag bits, discs, picks, and other cutters, and retention/mounting hardware).
 - One (1) spare main bearing assembly and seals available for replacement. The spares shall be identified and available for delivery to the site within three weeks to avoid delay. The spare parts may be used, provided they are rebuilt and in as-new condition and so certified in writing by original TBM manufacturer.
 - For an EPB TBM, one (1) spare screw conveyor or, for slurry TBM, a major slurry pump shall be identified and available for delivery to the site to avoid delay. The spare may be used, provided it is rebuilt and in as-new condition and so certified in writing by original TBM manufacturer.
 - Special hydraulic rams, hydraulic hoses, and components not available locally.

- Seals, o-rings, gaskets and all other components not available locally.
- Special electrical and mechanical components including two spare drive assemblies (gear box and motor). Spare hydraulic pumps and motors (major sized)
- Spare conveyor drive unit for EPB TBM
- Sufficient spare parts for efficient maintenance of track and rolling stock.

TUNNEL SYSTEMS AND PLANT:

- Compressed Air Equipment for access to the tunnel face and pressure chamber behind the cutterhead,
 - Provide either on the TBM or at the surface on site, a hyperbaric chamber for decompression of workers. For surface on-site chamber, provide a pressurized transport module for personnel exiting the TBM pressurized chamber until they reach the hyperbaric chamber on the surface.
 - Provide TBM with a compressed air man-lock and a separate equipment air lock and associated compressed air equipment designed for the maximum hydrostatic pressure to which the tunnel is exposed.
 - The hyperbaric system shall be maintained such that a pressurized intervention can be carried out at any time within 4 hours of the decision to carry out such an intervention. The hyperbaric consultant shall be present on site for the first three interventions at a pressure exceeding 3.5 bars (if any), and shall be available for advice and review at any time during tunnelling.
 - Design and operation of the airlock, medical lock and compressed air work and systems shall conform to the most stringent of all applicable local, Provincial, and Federal regulations for working in compressed air.
 - Provide efficient means of purging the forward chamber of hazardous gases before entry.
 - Comply with requirements of CAN/CSA-Z275.3-09.
 - Telephone within the compressed air lock and connection for telephone within Excavation Chamber.
 - Breathing masks with independent air supply for welding within the Excavation Chamber.
 - Provide appropriate materials handling equipment to permit the safe passage of excavation tools and other materials from the end of the segment feeder into the Excavation Chamber.
- Electrical System:
 - Electrical Systems for the TBM and trailing gear essential services shall be designed according to CEC Class 1 Zone 2 standards for potentially gassy locations and all other requirements set forth by WorkSafeBC and CSA Standard CAN/CSA-M421-93, Use of Electricity in Mines or other applicable regulatory agencies. Power interrupt that shall automatically shut down power to the TBM and trailing equipment upon detection of an air quality event such as explosive or toxic gas levels exceeding the regulation limits.

- The primary power distribution system shall have means for limiting high-voltage fluctuations when starting up or shutting down the TBM. Lighting Systems:
 - Primary lighting system for the entire length of the tunnel to CEC Class 1 Zone 2 as minimum standard.
 - Additional lighting in tunnel shall be sufficient for inspection of construction operations by the Province's Representative.
 - Flashlights shall be approved by WorkSafeBC as "permissible".
- Electrical provisions for ventilation systems shall be in accordance with the CEC minimum Class 1 Zone 2 specification, WorkSafeBC regulations and CSA Standard CAN/CSA-M421-93.

VENTILATION SYSTEM:

- Ventilation system design shall meet or exceed minimum requirements of WorkSafeBC regulations and CSA Standard CAN/CSA-M421-93.

HEALTH AND SAFETY EQUIPMENT:

- All equipment shall be rated at minimum for use in CEC Class 1 Zone 2 hazardous locations.
- Continuous air quality monitoring on the TBM with readings captured by the TBM Data Acquisition System and recorded by the data logger at intervals of 10 seconds or less.
- Design the alarm system to disengage the TBM, at no more than 20 percent of LEL for methane or any other combustible gas.
- Position sensors at locations that provide the most effective measurement of combustible and toxic gases. Do not place sensors within a fresh air stream.

6. SUBMITTALS FOR REVIEW

- Tunnel Boring Machine (TBM): Detailed description of the proposed TBM to be used including preliminary drawings and plans within 90 calendar days of the Effective Date to include.
 - General arrangement drawings from TBM manufacturer showing details of TBM and backup equipment layout including detailed scale drawings with sufficient vertical and horizontal sections at tunnel axis and cross sections to clearly identify the different components of the TBM. Show the following features of the TBM:
 - Complete technical description and detailed general arrangement drawings of TBM and backup equipment, including cutters and cutterhead, conditioning system, thrust, articulation, and steering systems, drive system, muck system, main bearing and tail seals, guidance system, probe hole drilling system, segmental lining grouting system, gas monitoring system, fire suppression system, schematic electrical system, ventilation system, segment erector and

the interface of TBM with the segmental lining system elements, muck transport system.

- Details of the tunnel spoil transport system and slurry treatment facility if applicable.
 - Provide detailed narrative supported with sketches demonstrating the suitability of the TBM and backup for tunneling in the ground conditions as determined by the Primary Contractor.
 - Provide a narrative description of how the working chamber is ventilated during manual intervention.
 - A complete technical description of the proposed TBM and all necessary backup equipment and systems for this project. Detail in submittal shall be sufficient to demonstrate that all aspects of the specification requirements are met. The proposed TBM manufacturer shall certify in writing that TBM and backup equipment and systems meet the requirements of the Project Agreement.
- Provide written certification from TBM manufacturer of full and complete design coordination between TBM manufacturer and liner manufacturer. Include a written certification by both manufacturers affirming the compatibility of total TBM system and back-up equipment with lining, segment erector and backfill grout injection system.

SECTION 02430

TUNNEL GROUTING

EXECUTION

Backfill Grouting shall be used to fill the annular space between the tunnel lining and the excavated surface.

Contact Grouting shall be used to fill voids and/or leaks between the initial ground support/excavated surface and the final concrete liner in the tunnels.

The Primary Contractor shall be responsible for laboratory testing that shall be performed by an independent testing company/firm with an established record of at least three years of experience in performing the standardized tests that are required for the grouting operations.

Rejection criteria for aged grout will be strictly enforced. Grout that is not placed within two hours of the time of mixing shall not be used unless a retarder specially formulated to suspend hydration is used.

The amount of grout used shall be monitored and compared to the theoretical quantity. In the event that the quantities differ significantly steps will be taken to determine the cause and any remedial action to correct the problem shall be taken.

Primary backfill grouting of the annular space behind the segments shall take place continuously and simultaneously as the TBM progresses forward.

Backfill grouts and contact grouts shall remain effective for the design life of 100 years. The grouts shall not degrade, shrink, or lose strength to an extent that the tunnel would be damaged or become unsafe or unserviceable as a result.

Should access holes be required through segmental lining, the Primary Contractor shall not compromise the structural integrity of the segment and will patch repair to the satisfaction of the Province's Representative.

Submittals for Review

- A. At least 60 days before commencing Tunnel construction, submit the following:
1. Resume(s) of the proposed grouting supervisor(s).
 2. Grout mixes, including proprietary mixes, and injection methods for each type of grout, certified by a registered Professional Engineer. Information given shall include:
 - a. Design cylinder strengths after TBM has advanced by one ring, five rings, ten rings and 28 days since time of injection of backfill grout. Assume maximum anticipated TBM advance rate as stated in submitted work plan. Include cylinder tests (compressive strength) of standard cylinders from trial mix, tested for compressive strength at the required times.
 - b. Description of how grout provides the required strength, stiffness, gel and set time characteristics consistent with the planned rates of advance of the TBM and sequential excavations. Logic used to design grout composition and pressures as a function of tunnel depth, rate of advance, ground, and groundwater conditions.
 3. Manufacturer's product data, material safety data sheets, material qualification data and certification that materials meet specification materials for each type of grout.
 4. General Grouting Procedures:
 - a. Procedures for disposal of waste grout and water
 - b. Acceptance criteria for completed grouting
 - c. Methods for assuring that grout injection does not damage surrounding or adjacent infrastructure, structures, facilities and utilities.
 5. Backfill Grouting: Description and Shop Drawings of grouting equipment, its arrangement, grouting procedures, methods, and measures for ensuring voids or loosened/disturbed zones are filled and stabilized.

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6. Pre-Excavation Grouting:
 - a. Primary Contractor's geotechnical engineer's evaluation of ground conditions encountered.
 - b. Procedures for grouting ahead of sequential excavations, description and Shop Drawings of grouting equipment, their arrangement and grouting procedures and methods.
 - c. Procedures of drilling grout holes, method of preventing excessive groundwater inflow, and methods of preventing excessive grout injection controlled by adjustment of setting time, viscosity, pressures, etc. Location of grout holes relative to proposed excavations, including spacing, orientation relative to alignment, and overlap.
 7. Contact Grouting: Description and Shop Drawings of grouting equipment, their arrangement, grout pipe materials, grouting procedures and methods, and measures for ensuring the integrity of the precast segmental lining and final cast-in-place concrete, where applicable.
 8. Extended Grout Holes in Precast Segments: Diameter of drilled holes and the means of drilling and patch repair.
 9. Grouting through segment lift/grouting hole in key segment: Procedures to prevent grout pressure from dislocating key.
 10. Coring and testing procedures for determining strength of in-place backfill grout.
 11. Name, address, qualifications and record of experience of independent testing laboratory(s).
- B. Submit certifications of calibration of pressure gauges and flow meters tested using procedures and frequency recommended by manufacturer.
 - C. Submit description of planned and contingency grouting procedures including sequences and procedures for injection, and procedures for altering mix proportions based on

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observed grout takes, and modifications to grouting procedures based on observed settlements, heave or grout escapes.

D. Submit forms to be used in completing daily records.

Submittals for Review

- A. Prepare, maintain, and provide on a daily basis, daily records including the following performance records for each shift of grouting, and for each type of grouting (backfill, pre-excavation and contact):
1. Records including specific grout holes drilled and grouted, their length, diameter, orientation, and as-built location.
 2. Start and finish times and dates for drilling of grout holes and injection of grout.
 3. All grout mix data including batch number, mix proportions, viscosity, setting times, and any modifications made to the mix during grouting operations.
 4. Pressures (initial, average, and final) and rates of pumping.
 5. Volume of grout pumped into each hole/packer and through the backfill grout injection system.
 6. Descriptions of interruptions or other difficulties experienced in grouting operations, including grout escapes and observations during drilling noting water inflow, hole instability and voids/loose ground encountered.
 7. Grout mix routine test results with backup methodology to demonstrate grout design valid for 100 year design life of project.
- B. Prepare, maintain, and provide the following performance records on a weekly basis for backfill grouting:

STRICTLY CONFIDENTIAL

1. Calculate a rolling 10 ring average grout take (volume) and compare with submitted proposed minimum/maximum volume and theoretical volume, which shall be provided, in both hard and electronic copies.
- C. Provide records of strength of in-place (cored) backfill grout within 24 hours of testing.

STRICTLY CONFIDENTIAL

1.0 GENERAL

1.1 Contents

1.1.1 This Section specifies finishing requirements for cast-in-place concrete surfaces including:

- 1.1.1.1 as-cast and treated formed horizontal and vertical surfaces,
- 1.1.1.2 as-cast and treated unformed horizontal surfaces,
- 1.1.1.3 sloped and irregular surfaces,
- 1.1.1.4 repair of as-cast and treated surfaces
- 1.1.1.5 patching of tie holes and post-tensioning blockouts, grout inlets and vent holes.

1.2 References

1.2.1 All concrete finishing Work shall conform to the requirements of the following standards:

- 1.2.1.1 CSA - A23.1-94: Concrete Materials and Methods of Concrete Construction
- 1.2.1.2 ACI 303.1-97: Standard Specification for Cast-in-Place Architectural Concrete
- 1.2.1.3 ACI 309.2R-90: Identification and Control of Consolidation-Related Surface Defects in Formed Concrete

1.3 Definitions

1.3.1 The following definitions have been used in this Section:

1.3.2 As-cast surface - Untreated surface in which the mortar is the principle visible constituent, and the texture is that which is imparted by the formwork surface.

1.3.2.1 Type 1 - not exposed to public view

1.3.2.2 Type 2 - exposed to public view

1.3.3 Treated surface - surface which is treated in place by removal of the surface mortar, thus wholly or partially obscuring the form texture.

1.3.4 Non-structural surface defect - an imperfection, irregularity, fin, projection, hole, honeycomb area, or discontinuity visible on the surface of a concrete

STRICTLY CONFIDENTIAL

element impairing the appearance but not the structural integrity of the concrete element.

1.3.4.1 Minor - having a surface area of less than 700mm^2 , a maximum surface dimension of less than 50mm, and a maximum depth of 35mm from the adjacent surface.

1.3.4.2 Major - having a surface area of more than 700mm^2 , a maximum surface dimension of more than 50mm, or a depth of more than 35mm from the adjacent surface.

1.3.5 Structural defect - a surface or internal defect impairing the structural capacity or durability of the concrete element.

1.3.6 Discrete surface - a concrete surface at least 1.0 m^2 in area, bounded on all sides by corners each with an interior angle of less than 165° . Where a discrete surface has an area of less than 1.0 m^2 it shall be combined with one or more adjacent discrete surfaces to form a discrete surface for the purpose of this Section. Where a discrete surface has an area of more than 50 m^2 , the requirements of this Section shall apply to any portion of the surface not more than 50 m^2 in area and not longer than 10 m in any one dimension between corners.

1.4 **Quality Control**

1.4.1 The Primary Contractor shall perform all work in accordance with the approved Quality Management Plan. The procedures, personnel, products, methods, and submittals noted in this section shall be considered a minimum requirement of that plan. Additional submittals, checklists, procedures and methods may be required to meet the requirements of the Primary Contract and fulfill the obligations of the Quality Management Plan.

1.4.2 The Primary Contractor shall submit a quality control plan outlining the procedures to be followed to ensure that the work is in compliance with the requirements of this Section.

1.4.3 Include proposed methods and materials for repair in the quality control plan to restore the strength and integrity of the member and to match the finish, colour and texture of the patch to that of the surrounding as-cast concrete.

1.4.4 Submit the quality control plan to the Designer for review in accordance with the requirements of this Section.

1.5 **Finish Quality**

- 1.5.1 The desired finish to the concrete elements is a smooth, as-cast, architectural quality finish with a minimum of defects and a minimum of repairs.
- 1.5.2 Structural defects to Type 1 and Type 2 surfaces shall be identified and reported to the Designer immediately. Structural defects shall not be repaired until inspected by the Designer and until the repair methods and materials have been authorized by the Designer in writing and in accordance with the Quality Management Plan.
- 1.5.3 Structural defects on Type 2 surfaces shall be repaired to reinstate the structural integrity as well as meeting the requirements for non-structural defects as specified herein.
- 1.5.4. Major, non-structural defects in Type 1 as-cast surfaces shall be repaired in accordance with Clause 3.4 of this Section if the aggregate surface area of the defects is less than 30% of the total area of a discrete surface. If the total surface area of the major, non-structural defects is more than 30% of the total area of a discrete surface, the concrete element containing that surface shall be rejected by the Designer, and shall be removed and replaced..
- 1.5.5 Major, non-structural defects in Type 2 as-cast surfaces shall be repaired in accordance with Clause 3.4 of this Section only if the aggregate surface area of the major non-structural defects is less than 10% of the total area of a discrete surface. If the total surface area of the major, non-structural surface defects is more than 10% of the total area of a discrete surface, the concrete element containing that surface shall be rejected by the Designer, and shall be removed and replaced.
- 1.5.6 Minor, non-structural defects in Type 1 as-cast surfaces need not be repaired.
- 1.5.7 Minor, non-structural defects in Type 2 as-cast surfaces shall be repaired in accordance with Clause 3.4 of this Section if the aggregate surface area of such defects is more than 5% but less than 10% of a discrete surface. If the total surface area of the minor, non-structural defects is 10% or more of the total area of a discrete surface. If the total surface area of the minor, non-structural surface defects is more than 10% of the total area of a discrete surface, the concrete element containing that surface shall be rejected by the Designer, and shall be removed and replaced.

STRICTLY CONFIDENTIAL

- 1.5.8 Minor, non-structural defects in treated surfaces shall be repaired in accordance with Clause 3.4 of this Section if the total surface area of such defects is more than 1% of the total area of a discrete surface. If the total surface area of such defects is more than 10% of the total area of a discrete surface, the concrete element containing that surface shall be rejected by the Designer and shall be removed and replaced.
- 1.5.9 Structural and non-structural defects in blockouts, pockets, etc. shall be patched in accordance with Clause 3.4 of this Section.
- 1.5.10 Form tie holes not otherwise being plugged shall be patched in accordance with Clause 3.4 of this Section.
- 1.5.11 Defective work requiring corrective action by the Designer also includes, but is not limited to:
- 1.5.11.1 Concrete incorrectly formed, or not conforming to the details or dimensions on the drawings or a concrete surfaces which does not meet tolerance requirements.
- 1.5.11.2 Concrete containing wood, cloth, cracks, surface crazing or other surface irregularities caused by sub-standard workmanship or defective curing.

2.0 PRODUCTS

2.1 Mixes

- 2.1.1 The Primary Contractor and the Designer to provide specifications for formwork as required for specific design and construction requirements.
- 2.1.2 Materials used to repair or patch surface defects shall be made of similar constituents and of approximately the same proportions as used for the concrete being patched, except that adjustments to the aggregate size and sand content may be made if required to provide similar finish to adjacent surfaces as determined by trial repair or patch. White Portland cement shall be substituted for a part of the grey Portland cement, for patching of Type 2 as-cast or treated surfaces, in order to produce a colour matching the colour of the surrounding concrete, as determined by a trial repair or patch. The quantity of mixing water shall be no more than necessary to facilitate handling and placing. The patching mortar shall be mixed in advance and allowed to stand with frequent manipulation with a trowel, without addition of water, until it has reached the stiffest consistency that will permit placing.

STRICTLY CONFIDENTIAL

2.1.3 Bonding grout shall be prepared using a mix of one part cement to one part fine sand passing a No. 30 mesh sieve, mixed to the consistency of thick cream and then well brushed into the surfaces.

2.1.4 A pre-approved latex type bonding agent may be added to the repair or patching material. Quantity and use of admixture shall be accordance with the manufacturer's specifications.

2.2 **Bonding Agent**

2.2.1 A pre-approved epoxy adhesive, used strictly in accordance with the manufacturers written specifications, may be used as a bonding agent.

2.3 **Non-Shrink Grout**

2.3.1 Non-shrink grout shall be non-metallic and shall develop a minimum compressive strength of 40 MPa in 28 days.

2.4 **Other Materials**

2.4.1 Other materials proposed for use shall be subject to approval by the Designer and will be considered based on compliance with requirements and successful performance in prototype or similar construction.

3.0 **EXECUTION**

3.1.1 Immediately after removal of formwork, concrete surfaces shall be inspected for defects. Repairable defects, as defined in Clause 1.5 of this Section shall be repaired in accordance with Clause 3.4 of this Section.

3.1.2 No repairs shall be made to concrete surfaces where the defects exceed the limits defined in Clause 1.5 and the Designer shall notify the Designer before the concrete is removed and replaced.

3.2 **Finishing of Formed Surfaces**

3.2.1 All concrete finishing work shall conform to the requirements of CSA-A23.1 except as specified herein.

3.2.2 The tolerances and limits to surface defects specified herein are not the limits to which concrete may be built or by which damaged form materials may be used. The tolerances and limits are allowed only for inadvertent or relatively infrequent irregularities. Practices and form materials are to be prohibited

where their use would result in the creation of additional irregularities, even those these would be within the limits specified.

- 3.2.3 Immediately after removal of formwork, all bolts, ties, nails or other metal not required for further construction purposes, shall be removed or cut back to a depth of at least 25mm from the surface of the concrete. The cut out areas and cavities shall be repaired immediately as specified in Clause 3.4 of this Section to prevent staining of adjacent concrete surfaces.
- 3.2.4 Any concrete plugs, formed in bleed holes in templates or similar devices, shall be removed and the surface finished smooth and even with the adjacent surfaces.
- 3.2.5 Surface irregularities, such as bulges, fins, lips or plugs shall be removed by chipping or grinding, and if necessary, shall be repaired in accordance with Clause 3.4 of this Section. Grinding, when used, shall not proceed until the concrete has sufficiently hardened to prevent dislodgement of coarse aggregate particles.

3.3 **Finishing of Unformed Horizontal Surfaces**

- 3.3.1 All exposed horizontal surfaces that are not intended to receive any additional concrete shall have a float finish as specified and shall conform accurately, within specified tolerance limits, to grades and elevations shown on the drawings. Finished surfaces shall be free from open texturing, plucked aggregate, and local projections. Further trowel, broom or special finishes shall be performed as specified and where shown or required.
- 3.3.2 Horizontal surfaces intended to carry additional concrete shall be thoroughly roughened to an amplitude of 5.0 mm and cleaned of laitance and loose concrete. This shall be performed by roughening of wet concrete, wet sandblasting, cutting with air-water jet, pneumatic scabbling or other suitable methods authorized by the Designer in writing, to expose clean and sound aggregate.
- 3.3.3 After the concrete has been placed, consolidated, struck off, and leveled, the concrete shall not be worked further until ready for floating. Floating shall begin when the water sheen has disappeared and when the surface has stiffened sufficiently to permit the operation. All high spots shall be cut down and all low spots filled during this procedure to produce a surface within the specified tolerance limits throughout. The surface shall then be re-floated immediately to a uniform sandy texture. Special care shall be taken in finishing areas between inserts, templates and other similar devices.

- 3.3.4 Trowelling shall mean finishing concrete surfaces with a machine or hand trowel fitted with metal blades. Trowelling shall only be performed on a surface that has previously been float finished. Two or more passes of the trowel shall be made within suitable time intervals to obtain a dense hard smooth surface. Trowelling by hand shall be performed only if required to remove irregularities where machine trowelling cannot be executed to create a suitable smooth surface. Tooled edges and joints shall be re-finished after trowelling to maintain uniformity and true lines.
- 3.3.5 Broom finish shall mean a fine, but slip-resistant, striated surface produced by brushing the newly troweled surface with a soft bristled broom. Brooming shall be performed when the concrete has been previously float finished and troweled and is sufficiently hard to retain the texture.
- 3.3.6 Saw-cut joints, when required or permitted by the Designer, shall be carefully timed with the set of the concrete. Cutting shall be started as soon as the concrete has hardened sufficiently to prevent aggregates being dislodged by the saw, and shall be completed before shrinkage stresses become sufficient to produce cracking.

3.4 **Repair of Surface Defects**

- 3.4.1 If proper and effective repair of a defect is not feasible, or the repair work carried out is not successful the elements affected shall be identified to the Designer and shall be removed and replaced.
- 3.4.2 The materials and methods used to repair the structural and non-structural defects shall be as authorized by the Designer in writing and in accordance with the Quality Management Plan.

3.5 **Patching**

- 3.5.1 Field post-tensioning blockout pockets shall be patched with non-shrink grout, as follows:
- 3.5.1.1 Grout shall be confined at open ends with a suitable mortar tight formwork. Before grouting, the area shall be thoroughly cleaned by light sandblasting and then blown clear with oil-free compressed air. Post-tensioning anchorages and corrosion systems shall be protected during sandblasting. After cleaning the concrete, bonding surfaces shall be coated with the specified epoxy bonding adhesive and then grouted. Mixing, handling and application of epoxy adhesive shall be in accordance with the manufacturers specifications.

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- 3.5.1.1.1 Grout patches shall be kept damp for a minimum period of seven days;
- 3.5.1.1.2 Field post-tensioning grout inlets and vent holes shall be filled with the patching mix and finished to match the adjacent surface;
- 3.5.1.2 Tie holes shall be cleaned and thoroughly dampened, and filled solid with patching mortar and finished as described in Clause 3.3 of this Section.. Precast cones shall not be used.

3.6 **Surface Tolerances**

- 3.6.1 Unless otherwise determined by the Designer , concrete surfaces shall meet the following tolerances:
 - 3.6.1.1 Horizontal or sloped concrete surfaces shall be true planes within 5.0 mm in 3.0 m as determined by a three-metre straight-edge placed anywhere on the surface in any direction. This tolerance is non-cumulative.
 - 3.6.1.2 Curved or complex shaped surfaces shall not deviate from the specified shape as dimensioned on the drawings by more than 5.0 mm, as measured by a survey.
 - 3.6.1.3 Where the discrete surface of the concrete element is 3 m or less in one dimension or less than 9 m² in area, the tolerances shall be half of the above.
- 3.6.2 Conformance to tolerance limits shall be checked by Designer at any time after the curing period.

3.7 **Protection**

- 3.7.1 Take every precaution to prevent damage, abrasions and staining of surfaces and edges of concrete during the Work. Provide plywood or insulation protection and polyethylene wrappings or other means as required to concrete elements that may be damaged by subsequent construction activities. Remove protective coverings at completion of construction.
- 3.7.2 Barricades shall be erected to prevent traffic on newly finished surfaces.

END OF SECTION

STRICTLY CONFIDENTIAL

1.0 GENERAL

1.1 Contents

1.1.1 This Section specifies the requirements for sandblasted concrete.

1.1.2 Sandblasted concrete shall consist of concrete with a textured surface having uniform colour and some exposed fine aggregate produced by pneumatically projecting silica sand or other abrasive materials onto the concrete surface.

1.2 Quality Control

1.2.1 The Primary Contractor shall perform all work in accordance with the approved Construction Quality Management Plan. The procedures, personnel, products, methods, and submittals noted in this Section shall be considered a minimum requirement of that plan. Additional submittals, checklists, procedures and methods may be required to meet the requirements of the Contract and fulfill the obligations of the Quality Management Plan.

1.2.3 Mix Design:

1.2.3.1 to minimize variations in colour and shading and ensure a high degree of visual conformity, only one concrete mix will be permitted for areas subject to blasting;

1.2.3.2 sufficient quantities of all ingredients required to complete the Work using the same design mix must be available; and

1.2.3.3 once the design mix has been reviewed by the Designer, it shall not be varied as to source, quantity, quality, grading of materials, or proportioning, or any other aspect of the materials affecting the design.

1.2.5 Pre-Construction Test:

1.2.5.1 the Primary Contractor shall cast and sandblast sample panels on site using proposed equipment, materials, personnel and procedures;

1.2.5.2 for each mix selected for use in areas designated for blasting treatment, the Primary Contractor shall make at least one sample panel measuring 600mm by 600mm. The panels shall be cured in accordance with CAN/CSA-A23.1-M;

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- 1.2.5.3 the sample panels shall be sandblasted with different abrasives to obtain the desired colour and texture and then reviewed by the Designer and the Province's Representative;
- 1.2.5.4 the Primary Contractor shall cast and sandblast a test wall mock-up 1200mm by 2400mm using the selected reference panel design mix. The test wall mock-up shall demonstrate to the satisfaction of the Designer and Province's Representative:
- 1.2.5.4.1 form finish including colour and texture;
 - 1.2.5.4.2 form ties and form tie holes;
 - 1.2.5.4.3 joint types in designed structure;
 - 1.2.5.4.4 method of curing;
 - 1.2.5.4.5 method of cleaning and patching of concrete surfaces; and
 - 1.2.5.4.6 age of concrete when sandblasted.

2.0 PRODUCTS

2.2 Abrasives

- 2.2.1 Abrasive materials used for blasting operations are silica sand, certain hard angular sands, blasting grit, aluminum carbide and black slag particles.
- 2.2.2 The abrasive material selected from trial tests on sample panels shall be used throughout the Work.
- 2.2.3 The abrasives material shall be non-staining, free of deleterious substances and supplied in sealed sacks.

2.3 Water

- 2.3.1 Water for use in Portland cement concrete for curing and for dust control, shall be in accordance with Section 03060, "Concrete, General".

2.4 Air Supply

- 2.4.1 Air supply system shall be capable of supplying a minimum air pressure at the nozzle of 690 kPa.

STRICTLY CONFIDENTIAL

- 2.4.2 The nozzle shall be venturi type with a minimum inside diameter of 10mm and supply hose line with a minimum inside diameter of 40mm to maintain the abrasive in continuous suspension while travelling through the hose.
- 2.4.3 Supply systems that deliver air contaminated by oil shall not be used.
- 2.4.4 The nozzleman shall be protected by a hood supplied with filtered air.

3.0 EXECUTION

3.1 Placing and Fastening of Reinforcement

- 3.1.1 The fabrication and placement of reinforcing steel shall be in accordance with Section 03060, "Concrete, General", except as noted in this Section.
- 3.1.2 Plastic-protected spacers, chairs and hangers shall be used. The plastic shall have a thickness of not less than 5mm at the point of contact with the form and should be coated to a point at least 15mm from the face of the form.
- 3.1.3 The plastic supports and spacers shall be non-staining and shall not chip, peel, crack, or deform under normal job conditions and temperatures and shall be of suitable colour and design to reduce their visibility in the finished concrete.
- 3.1.4 Galvanized supports and pre-cast concrete mortar blocks will not be permitted.

3.2 Formwork

- 3.2.2 All joints shall be sealed to prevent leakage using pressure sensitive tape on the inside of the forms and as demonstrated on the test wall mock-up. Care must be taken to prevent displacement of the tape during concrete operations. Taped joints shall be inspected prior to placing concrete to be sure the tape has not moved.
- 3.2.3 Form release agents shall be applied uniformly to thoroughly clean surfaces and shall be of a type consistent with the required finish and shall be used at a rate suitable for easy release and stripping of the forms. The form release agent shall be demonstrated on the test wall mock-up to be compatible with the blasting treatment. The same release agent is to be used for the entire Work.
- 3.2.4 The removal of formwork shall be scheduled so that adjacent formwork is stripped at the same age to limit variations in concrete colour hues.

3

3.4 Sandblast Finishing

STRICTLY CONFIDENTIAL

- 3.4.1 The Primary Contractor shall sandblast the concrete surface to match the finish, colour, and texture of the reviewed sample panel and test wall mock-up:
- 3.4.1.1 although reference is made to sandblasting, the actual abrasive used shall be selected from the trial tests on sample panels; and
- 3.4.1.2 a sandblasting should be sufficient to remove the cement matrix and expose fine aggregate with no reveal. The reveal is defined as the projection of the coarse aggregate from the matrix after exposure. The degree of sandblasted finish shall correspond to the reviewed sample panel.
- 3.4.2 The Primary Contractor shall ensure that all surface imperfections have been repaired, form tie holes filled, stains removed and a smooth formed surface exists prior to commencing sandblasting.
- 3.4.3 The Primary Contractor shall commence sandblasting when the concrete has achieved the same age as that used for the test wall mock-up:
- 3.4.3.1 all subsequent blasting shall be done at the same concrete age for uniformity of appearance;
- 3.4.3.2 formwork shall not be removed until the concrete has achieved specified strength; and
- 3.4.3.3 the Primary Contractor shall ensure that construction activities will not result in accidental damage to finished surface areas.
- 3.4.4 The Primary Contractor shall ensure that all equipment including back-up systems, if so required, are functioning properly before commencing the sandblasting operation. The nozzleman by the design of the hood, scaffold, hose and lighting shall have a uniform unobstructed view of the work surface. The hood for the applicator shall be supplied with filtered compressed air. Adjacent work, other construction activities and personnel shall be protected from the sandblasting operation.
- 3.4.5 Water shall be used in the blasting process to control dust. When this technique is utilized, abraded mortar should be continually washed from previously sandblasted areas to prevent staining.
- 3.4.6 The nozzle shall be held at a consistent predetermined distance and position from the surface to be treated so that the stream of flowing material is applied as nearly as possible at right angles to the surface.
- 3.4.7 Only the areas indicated on the Construction Drawings shall be sandblasted. The Primary Contractor shall ensure that all surfaces which are not subject to this

STRICTLY CONFIDENTIAL

treatment are protected during sandblasting operations and any surfaces so damaged shall be repaired.

3.5 **Defective Work**

- 3.5.1 It is the intent of these Specifications that any repairs and patching of the concrete surface shall take place prior to commencing the sandblasting operation and that procedures for repair and patching shall be developed on the test wall mock-up.
- 3.5.2 The completed sandblasted concrete surface will be considered acceptable if it has a pleasing appearance with minimal colour and texture variations and minimal surface defects when viewed at a distance of approximately four metres.
- 3.5.3 If, in the opinion of the Designer, the completed sandblasted concrete surface has major defects and does not meet the specified requirements, then a repair and replacement procedure shall be developed by the Primary Contractor for the Designer's review, and Work completed by the Primary Contractor.

END OF SECTION

STRICTLY CONFIDENTIAL

SECTION 03360

ARCHITECTURAL CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

1.1.1 Design concrete mix, supply necessary materials and install architectural concrete as indicated and specified.

1.2 REFERENCES

1.2.1 ACI 301, Specification for Structural Concrete.

1.2.2 ACI 303.1, Specification for Cast-in-Place Architectural Concrete.

1.2.3 ACI 308 Guide to Curing Concrete.

1.2.4 ACI 309 Identification and Control of Consolidation-Related Surface Defects in Formed Concrete.

1.2.5 ACI 117 Tolerances for Concrete Construction.

1.2.6 CAN/CSA-A23.1-A23.2-00, Concrete Materials and Methods of Concrete Construction /Methods of Test for Concrete.

1.2.7 CAN/CSA-A5-93, Portland Cement.

1.2.8 CSA Standard A23.1 "Concrete Materials and Methods of Concrete Construction."

1.2.9 CSA Standard A23.2 "Methods of Test for Concrete."

1.2.10 CSA Standard A23.3 "Code for the Design of Concrete Structures for Buildings."

1.2.11 CAN/CSA-A3000, Cementitious Materials Compendium (includes CAN/CSA-A5, CAN/CSA-A23.5, A362, A 363.

1.2.12 CSA 269.3-M92 Concrete Formwork.

1.3 SUBMITTALS

1.3.1 The Primary Contractor will retain submittal review records for the following submittals and will make them available on request to the Province's Representative:

1.3.1.1 Product Data: For each type of product indicated.

STRICTLY CONFIDENTIAL

- 1.3.1.2 Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
- 1.3.1.3 Proposed form release agent.
- 1.3.1.4 Proposed surface retarder.
- 1.3.1.5 Proposed special admixtures to address specific issues
- 1.3.2 Formwork Shop Drawings: Show formwork construction including form-facing joints, rustications, construction and contraction joints, form joint-sealant details, form tie locations and patterns, inserts and embedments, cutouts, cleanout panels, and other items that visually affect cast-in-place architectural Concrete.
- 1.3.3 Samples: For each of the following materials:
 - 1.3.3.1 Form-facing panel.
 - 1.3.3.2 Form ties.
 - 1.3.3.3 Form liners.
 - 1.3.3.4 Coarse- and fine-aggregate gradations.
 - 1.3.3.5 Chamfers and rustications.
 - 1.3.3.6 Other forming materials.
- 1.3.4 Placement Schedule: Submit concrete placement schedule before start of placement operations. Include locations of all joints including construction joints.
- 1.4 QUALITY ASSURANCE
 - 1.4.1 Pre-installation Conference:
 - 1.4.1.1 Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place architectural concrete to attend.
 - 1.4.1.2 Review concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction joints, forms and form-removal limitations, reinforcement accessory installation, concrete repair procedures, and protection of cast-in-place architectural concrete.

1.4.2 Mock-ups: Before casting architectural concrete, build mock-ups to demonstrate aesthetic effects and qualities of materials and execution. Build mock-ups to comply with the following requirements, using materials indicated for the completed Work:

1.4.2.1 Demonstrate curing, cleaning, and protecting of cast-in-place architectural concrete, finishes, and contraction joints, as applicable.

1.4.2.2 Maintain mock-ups during construction in an undisturbed condition as a standard for judging completed Work.

1.4.2.3 Approved mock-ups may become part of completed Work if undisturbed at time of Substantial Performance.

1.5 TOLERANCES

1.5.1 Concrete surfaces shall meet the following tolerances:

1.5.1.1 Horizontal or sloped concrete surfaces, shall be true planes within 3 mm in three metres, as determined by a three metre straightedge placed anywhere on the surface in any direction. This tolerance is non-cumulative.

1.5.1.2 Curved or complex shaped surfaces shall not deviate from the specified shape as dimensioned by more than 5mm, as measured by a survey.

1.5.1.3 Where the discrete surface of the concrete element is 3 metres or less in one dimension or less than 9 square metres in area, tolerances shall be one-half of the above.

1.5.2 Conformance to tolerance limits shall be checked at any time after the curing period.

1.6 DEFINITIONS

1.6.1 “Architectural Concrete”: Concrete exposed to view in both interior and exterior areas of passenger Stations and Other Fixed Facilities and at the exterior surfaces of the tunnel portals. ‘Architectural Concrete’ will include ‘Smooth-formed Concrete’ for exposed concrete in public areas of stations and at tunnel portals, ‘Concrete to be Painted’ for exposed concrete in Ancillary Spaces and Other Fixed Facilities, and ‘Finishes to Floors and Slabs’ for exposed and covered concrete floors.

PART 2 - PRODUCTS

2.1 FORM-FACING MATERIALS

2.1.1 Form-Facing Panels for Smooth-surfaced finishes: As appropriate, utilize either:

2.1.1.1 Smooth-faced steel, glass-fibre-reinforced plastic, or other approved non-absorptive panel materials that will provide continuous, true, and smooth

- architectural concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.
- 2.1.1.2 Smooth-faced exterior-grade plywood panels, non-absorptive, that will provide continuous, true, and smooth architectural concrete surfaces complying with CAN/CSA A23.1 and CAN S269- 3-M92.
- 2.1.1.2.1 High-density overlay, Class 1, or better.
- 2.1.1.2.2 Medium-density overlay, Class 1, or better, mill-applied release agent and edge sealed.
- 2.1.2 Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fibre-reinforced plastic, paper, or fibre tubes that will provide surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.
- 2.1.3 Pan-Type Forms: Glass-fibre-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.
- 2.1.4 Form Liners: Units of face design, texture, arrangement, and configuration to match design reference sample. Furnish with manufacturer's recommended liquid-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent surface treatments of concrete.
- 2.1.5 Rustication Strips: Metal, rigid plastic, or dressed wood with sides bevelled and back kerfed; non-staining; in longest practicable lengths
- 2.1.6 Chamfer Strips if indicated: Metal, rigid plastic, elastomeric rubber, or dressed wood, 19 by 19 mm (3/4 by 3/4 inch), minimum; non-staining; in longest practicable lengths.
- 2.1.7 Form Joint Tape: Compressible foam tape; pressure sensitive; AAMA 800, "Specification 810.1, Expanded Cellular Glazing Tape"; minimum 6 mm (1/4 inch) thick.
- 2.1.8 Form Joint Sealant: Elastomeric sealant complying with ASTM C920, Type M or S, Grade NS, that adheres to form joint substrates.
- 2.1.9 Sealer: Penetrating, clear, polyurethane wood form sealer formulated to reduce absorption of bleed water and prevent migration of set-retarding chemicals from wood.
- 2.1.10 Form-Release Agent: Commercially formulated colourless form-release agent that will not bond with, stain, or adversely affect architectural concrete surfaces and will not impair subsequent treatments of those surfaces.
- 2.1.10.1 Formulate form-release agent with rust inhibitor for steel form-facing materials.

- 2.1.11 Surface Retarder: Chemical liquid set retarder, for application on form-facing materials, capable of temporarily delaying final hardening of newly placed concrete surface to depth of reveal specified.
- 2.1.12 Form Ties: Factory-fabricated, internally disconnecting ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
 - 2.1.12.1 Furnish ties with tapered tie cone spreaders that, when removed, will leave holes 25 mm (1 inch) diameter on concrete surface.
 - 2.1.12.2 Furnish internally disconnecting ties that will leave no metal closer than 38 mm (1-1/2 inches) from the architectural concrete surface.
 - 2.1.12.3 Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.
- 2.2 MATERIALS
 - 2.2.1 Reinforcement:
 - 2.2.1.1 Reinforcing steel for applications where welded splices and connections are not required, shall be Grade 400W (weldable), conforming to CSA G30.18-M, Stirrups and ties of Grade 400W material shall meet the bending and elongation requirements of Grade 300W steel.
 - 2.2.1.2 Reinforcing steel for applications where welded splices and connections are required, shall be Grade 400W, conforming to CSA G30.18-M.
 - 2.2.1.3 Reinforcing steel for applications where fabricated bar mats are required, shall be Grade 400 bars conforming to CSA G30.5-M for smooth bars and to CSA G30.15-M for deformed bar mats.
 - 2.2.1.4 Plain steel wire reinforcement, if required, shall conform to CSA G30.3-M.
 - 2.2.2 Concrete Materials
 - 2.2.2.1 Cement: Type GU, conforming to CSA A3001. Cement shall originate from the same mill.
 - 2.2.2.2 Fine and Coarse Aggregate: Conforming to CAN/CSA A23.1, normal density, natural clean stone. Free from alkali aggregate reaction.
 - 2.2.2.3 Fly ash: CSA A23.5, Class C or F
 - 2.2.2.4 Ground Granulated Blast Furnace Slag: ASTM C989, Grade 100 or 120.
 - 2.2.2.5 Water: Potable and complying to ASTM C94

2.2.3 Admixtures

2.2.3.1 Air-entraining admixtures: conform to CSA-A23.1, Section 6.

2.2.3.2 Use of accelerating or set retarding admixtures during cold or hot weather placing is subject to Engineer approval. Do not use admixtures containing calcium chloride or thiocyanate. Chemical admixtures in Exposure Class C-1 concrete shall be free of chloride ions.

2.2.3.3 Verify all admixture products are fully compatible with each other and will not adversely affect the approved finish quality of the concrete or approved specified finishes applied to the concrete where applicable

2.3 ACCESSORIES

2.3.1 Waterstops: Flexible Rubber Waterstops: CE CRD-C 513, non tapered for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes. Profile and dimensions as indicated.

2.3.1.1 Greenstreak.

2.3.1.2 Progress Unlimited, Inc.

2.3.1.3 Williams Products, Inc.

2.3.1.4 Or approved alternative.

2.3.2 Self-Expanding Butyl Strip Waterstops: Manufactured rectangular or trapezoidal strip, butyl rubber with sodium bentonite or other hydrophilic polymers, for adhesive bonding to concrete, 19 by 25 mm (3/4 by 1 inch).

2.3.2.1 Colloid Environmental Technologies Company; Volclay Waterstop-RX-101T.

2.3.2.2 Greenstreak; Swellstop.

2.3.2.3 Henry Company, Sealants Division; Hydro-Flex.

2.3.2.4 TCMiraDRI; Mirastop.

2.3.2.5 Or approved alternative. Concrete Curing and Sealing Compound: To ASTM C309.

2.4 FINISHES

2.4.1 Colour finishes to be uniform colour from locally available non-premium material..

2.4.2 Hardener Sealer:

- 2.4.2.1 PS, ACER and Transformer Room slabs - Non-metallic material composed of a premixed blend of Portland cement and synthetic oxide with a Moh's hardness of not less than 8 and a minimum compressive strength of 55 MPa at 28 days.
- 2.4.3 Sealer for Exposed Slabs:
 - 2.4.3.1 Acrylic based, clear compound Florseal WB, by Sika, or approved alternative.
- 2.4.4 Water Repellent Coatings: Clear, penetrating sealer, silane and siloxane blends with 600 g/L (5 lb/gal.) or less of VOCs.
 - 2.4.4.1 Fabrishield 760, by Fabrikem.
 - 2.4.4.2 Hydrostop WB, by Kryton.
 - 2.4.4.3 Or approved alternative.

PART 3 - EXECUTION

3.1 FORMED FINISHES

- 3.1.1 Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Remove fins and other projections exceeding specified limits on formed-surface irregularities. Repair and patch tie holes and defects.
- 3.1.2 Rubbed Finish: Apply the following to smooth-form-finished as-cast concrete where indicated:
 - 3.1.2.1 Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform colour and texture. Do not apply cement grout other than that created by the rubbing process.
- 3.1.3 Concrete to be Painted: Best quality sacked and ground concrete finish. Projections greater than 1.5 mm (1/16") shall be ground flush and all voids larger than 3 mm (1/8") shall be flush filled using the technique described in Repairs to Defects.

3.2 FINISHING FLOORS AND SLABS

- 3.2.1 Finishing shall conform to CSA-A23.1 - Section 7.5 as a minimum..
- 3.2.2 Floor finishes shall be Class A "Institutional and Commercial Floors".
- 3.2.3 Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power driven floats. Re-straighten, cut down high spots, and fill

- low spots. Repeat float passes and re-straightening until surface is left with a uniform, smooth, granular texture.
- 3.2.3.1 Apply float finish to surfaces to receive trowel finish and to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, and as indicated.
- 3.2.4 Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and re-straighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
- 3.2.4.1 Apply a trowel finish to surfaces exposed to view or to be covered with resilient flooring, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
- 3.2.5 Broom Finish: Apply a broom finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated.
- 3.2.5.1 Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.
- 3.2.6 Floor Hardener and Sealer:
- 3.2.6.1 Apply in strict accordance with manufacturer's instructions.
- 3.3 PROTECTION, CLEANING AND SEALING
- 3.3.1 Protection:
- 3.3.1.1 Protect architectural concrete from damage by the elements and defacement during construction operation.
- 3.3.1.2 Protect corners and surfaces subject to damage with boards or hoardings.
- 3.3.1.3 Keep exposed concrete free from laitance caused by spillage, leaking forms or other contaminants. Do not permit laitance to penetrate, stain or harden on surfaces which have been sandblasted.
- 3.3.1.4 Protect exposed reinforcing steel in architectural concrete to prevent staining of surfaces of concrete due to rust and corrosion. If rust or corrosion does occur, remove it immediately to avoid permanent staining.
- 3.3.1.5 Protect corners, edges, and surfaces of cast-in-place architectural concrete from damage; use guards and barricades.
- 3.3.1.6 Protect cast-in-place architectural concrete from staining, laitance, and contamination during remainder of construction period.

3.3.2 Cleaning:

- 3.3.2.1 Immediately prior to application of sealer, thoroughly clean surfaces and maintain free of foreign materials such as sand, chips and dust from sandblasting and bushhammering operations. Rinse surfaces which are cleaned with a sealant manufacturer recommended cleaning solution and allow drying before sealer application.

3.3.3 Sealing:

- 3.3.3.1 Apply two coats of sealer to exterior concrete surfaces, first coat pigmented where indicated, second coat clear in accordance to manufacturer's instructions. Use the same method of application throughout the entire job.
- 3.3.3.2 Provide anti-graffiti coating.
- 3.3.3.3 Clean cast-in-place architectural concrete surfaces after finish treatment to remove stains, markings, dust, and debris.
- 3.3.3.4 Wash and rinse surfaces according to concrete finish applicator's written recommendations. Protect other Work from staining or damage due to cleaning operations.
- 3.3.3.5 Do not use cleaning materials or processes that could change the appearance of cast-in place architectural concrete finishes.

END OF SECTION 03360

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SECTION 03370

SHOTCRETE

Regulatory Requirements

All work shall comply with WorkSafeBC safety requirements for working platforms or lifting equipment, and personal protective equipment.

Uniformity of Materials

In production shotcrete work, use the same cement, aggregate and water used in accepted test areas, test panels and test units. Maintain specified strength.

Source Limitations

Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.

Testing Agency Qualifications

Use an independent Testing Agency, as reviewed by the Province Representative, qualified to conduct the testing indicated.

Personnel conducting field tests as specified in this Section shall be qualified as ACI Concrete Field Testing Technician, Grade 1 in accordance with ACI standards, or an equivalent certification program.

Mix Design and Testing Prior to Production

Develop shotcrete mix by laboratory compatibility tests and field trials as specified, at least 60 days before the actual production application of shotcrete.

To ascertain compatibility of ingredients and optimum proportions, develop shotcrete mix having strength and characteristics meeting the requirements specified.

Perform compatibility tests to determine cements and additives to be used in field trial mixes. Determine initial and final set for additive concentrations of varying percentages of cement content by weight contemplated for use in the Work.

Make laboratory and field trial mixes with ingredients identical to those proposed for use in the Work.

Use accepted accelerating admixture to develop quick set. Sodium silicate admixtures shall not be used.

Determine time of setting in accordance with ASTM C266 using minimum possible time interval to attain proper mixing without impacting timing of disturbing initial set of paste.

Additional modifications to accommodate quick-set accelerators shall be reviewed by the Province Representative.

Perform standard concrete cylinder testing and pre-construction field trials.

Testing During Construction

From the in situ shotcrete lining, furnish core test specimens of size, quantity, frequency and from locations specified by the Province Representative.

Where applied shotcrete is less than 150mm in depth, make production test panels of size, quantity, frequency and from locations specified by the Province Representative and not less than one panel per day per crew.

Take additional cores from the completed Work on the date, and at the locations requested by the Province Representative.

Additional specimens will be required upon failure of original cores. Should additional specimens show acceptable strength, the Work will be accepted. If additional specimens show unacceptable strength, the Work will be rejected. Furnish additional specimens as necessary to satisfy the requirements of this Section.

Minimum clearance between core voids shall be 300mm. Plug voids caused by coring operation with material equal to shotcrete in-place and workmanship to ensure continuity of the lining with respect to strength and appearance.

Core holes shall not be arranged in a continuous row.

Shotcrete compressive strength requirements shall be determined by testing during construction for shotcrete as temporary liner,

Project Conditions

In applying shotcrete containing toxic ingredients, the nozzle personnel and helpers shall wear appropriate hoods supplied with filtered air, free of toxic or objectionable material. Gloves and necessary protective clothing shall also be worn. This protective equipment shall be specifically designed for protection from the particular materials included in the mix.

Ensure proper delivery, handling, and storage of materials to prevent any contamination, segregation, or damage.

Alkali hydroxides and other chemicals contained in shotcrete admixtures can cause skin and respiratory irritation. Adequate safety measures that are specifically designed to address the types of skin and respiratory irritations caused by shotcrete mix materials shall be taken as required in the Contractor's health and safety plan.

Working areas for shotcrete shall be well illuminated.

Shotcrete Mixes

Have aggregate and cement proportioned by an accepted batching plant based on weight or volume and in accordance with the applicable requirements.

Use the mixed material within one hour after adding cement, if no hydration control admixtures are used.

Accurately proportion and mix additive(s) with other ingredients.

Shotcrete Reinforcement

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Shotcrete may be reinforced with lattice girders and welded wire fabric or steel fibers as necessary to provide required strength.

Field Quality Control

The following describes the minimum inspection and testing required for the Work of this Section. The implementation does not relieve Contractor from the responsibility to provide the Work in accordance with the Contract, applicable codes, regulations, and governing authorities. The following testing and inspection elements are provided as a minimum list for the Contractor to use to generate his complete field quality control program.

At the start of the Project a batch plant inspection will be conducted to observe and evaluate the following for compliance with the Contract:

- Condition of batching equipment.

- Condition of materials.

- Type of materials used.

- Mixing time.

- Delivery time.

- Additional pertinent controls depending on weather, Work Site conditions, and other factors affecting the Work.

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- Inspect aggregate stockpiles and storage practices. Check for unacceptable material handling that may cause segregation or contamination within the stockpiles.
- Inspect trucks used to transport concrete to assure that they are clean and in a condition to deliver a uniform mix.

Shotcrete work will be subject to detailed inspection at the plant and in the field:

- Verify that shotcrete placement procedures are followed.
- Verify that cold-weather or hot-weather placing procedures of shotcrete are strictly followed.
- Verify that the shotcrete delivery tickets contain all necessary information.

If, upon reaching the Work Site, ready-mix shotcrete cannot be placed within the specified time limits, or if the type of shotcrete delivered is incorrect, the Province Representative shall reject the load for use, and it shall be removed from the Work Site.

A record of each field quality control inspection shall be submitted to the Province Representative, covering the quality and quantity of shotcrete materials, mixing and placing of shotcrete and the general progress of the Work.

Take prompt action to correct conditions that have resulted in or could result in submission of materials, products, or completed construction that do not conform to the requirements of the Contract.

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Inspection

Initial inspections shall be performed as soon as practical after each and every segment of the particular item of Work has been accomplished in order to provide visual evidence that the shotcrete mix and the application are producing the desired results.

Follow-up Inspections

Follow-up inspections shall be performed daily, and more frequently as necessary, and shall include continued testing and examinations to assure continued conformance with Contract requirements.

Defective Shotcrete

Shotcrete that lacks uniformity, exhibits segregation, honeycombing, lamination, shows cracking, lacks adequate bonding, lacks watertightness, or fails to meet the specified strength requirements shall be regarded as defective shotcrete.

The Province Representative shall reserve the right to halt further placement of shotcrete and/or to order removal of defective shotcrete and its replacement with acceptable corrective shotcrete.

Submittals for Review

- A. Submit qualifications for independent testing agency and personnel as indicated at least 30 days before commencing shotcrete application.
- B. ACI Certification, or equivalent, for each nozzle personnel demonstrating proficiency in applying shotcrete sideways horizontal, vertical, and overhead to the maximum thickness and with the same reinforcement as will be used in the production shotcreting

Submittals for Information

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- A. At least 30 days before commencing shotcrete application, submit:
1. Certified material test reports from a qualified testing agency without adjustment for type or size of specimen.
 2. Detailed plan showing methods and proportions to be used in such tests. The Province Representative may inspect tests and materials at any time.
 3. Curing procedures for production shotcrete.
- B. At least 60 days before commencing production shotcrete application, submit the following:
1. Product Data: For each type of manufactured material and product indicated.
 2. Samples: On completion of field trial, submit at least 54 test specimens of each trial mix, nine from each test panel, proposed for use in the Work together with relevant data that demonstrates conformance with specified requirements.
 3. Material Certificates signed by manufacturers, certifying that each of the following items, as applicable, complies with requirements:
 - a. Cementitious materials and aggregates
 - b. Steel fibers
 - c. Reinforcement
 - d. Admixtures
 - e. Curing materials
- C. Testing results from in-situ shotcrete lining placement during construction.

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SECTION 03450

PRE-CAST ARCHITECTURAL CONCRETE STAIR UNITS

PART 1 - GENERAL

1.1 **Work Included**

1.1.1 The Work shall include furnishing of labour, material, design, plant and equipment for fabrication and installation of precast concrete step units as indicated on the Definitive and Descriptive Drawings.

1.1.2 One-piece pre-cast concrete step units shall be utilized for public area stairs as shown in the Definitive and Descriptive Drawings VIA_RFP-A-1009 through VIA_RFP-A-1011. Where the tread or landing material is separate from the stair structure, the tread or landing material shall be mechanically anchored to the stringers at each side.

1.2 **Quality Control**

1.2.1 Precast concrete work shall be in accordance with CSA-A23.4 and CSA-A23.3.

1.2.2 Manufacturers and erectors of precast concrete elements shall be certified by CSA as meeting requirements of CSA A 251 for Class AC products, and shall have attestation of the Precast Concrete Institute under the Plant Certification Program.

1.3 **References**

1.3.1 CAN/CSA-A5: “Portland Cement”.

1.3.2 CSA-A23.1: “Concrete Materials and Methods of Concrete Construction”.

1.3.3 CSA-A23.2: “Methods of Test of Concrete”.

1.3.4 CSA-A23.4: “Code for the Design of Concrete Structure for Buildings”.

1.3.5 CSA-A23.4: “Precast Concrete Materials and Construction”.

1.3.6 CSA-A 179-M: “Mortar and Grout for Unit Masonry”.

1.3.7 CSA-A251-M: “Qualification Code for Manufacturers of Architectural and Structural Precast Concrete”.

1.3.8 ASTM CI71: “Specification for Sheet Materials for Curing Concrete”.

1.4 **Design Criteria**

1.4.1 Precast architectural concrete elements shall be designed to withstand handling loads, and anticipated live loads.

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- 1.4.2 Design loads and connections shall be in accordance with the British Columbia Building Code, in regards to temperature and earthquake.
- 1.4.3 The concrete shall be uniform in colour and texture.
- 1.4.4 The design shall specify concrete material, form material, release agents and admixes so as to achieve colour and texture uniformity throughout the project.
- 1.4.5 For additional requirements see Article 10 [Architecture], Part 2 of Schedule 4.

1.5 **Allowable Tolerances**

- 1.5.1 Allowable tolerances shall conform to the requirements of CSA-A23.4-, Section 10.

1.6 **Source Quality Control**

- 1.6.1 The Primary Contractor shall provide the Province's Representative with certified copies of quality control tests related to the Contract as specified in CAN3-A23.4-M.

1.7 **Submittals**

- 1.7.1 The Primary Contractor shall submit two samples 300 x 300 x 50 mm, of each of the product type, to indicate quality, colours and surface finish.

- 1.7.2 The Primary Contractor shall submit drawings bearing the stamp of a qualified professional structural engineer registered in the Province of British Columbia, together with required Letters of Assurance and showing complete information for the fabrications and installation of items supplied including:

- 1.7.2.1 dimensions and cross-section of item;
- 1.7.2.2 location, size and type of reinforcements;
- 1.7.2.3 provisions for lifting attachments;
- 1.7.2.4 erection procedure, sequence of erection, and all required handling equipment;
- 1.7.2.5 layout, dimensions and identification of each unit corresponding to the sequence and procedure of installation;
- 1.7.2.6 welded connections, indicted by AWS standard symbols;
- 1.7.2.7 insert details, connections and joints including accessories and construction at openings in precast units;
- 1.7.2.8 location and details of anchorage devices that are to be embedded in other construction; and

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- 1.7.2.9 locations of cut-outs for guardrail sleeves.
- 1.7.3 Manufacturer's data specifications and instructions for all precast products and materials supplied shall be submitted.
- 1.8 **Delivery, Storage and Handling**
- 1.8.1 Precast concrete units shall be delivered and unloaded at the Site on wood skids in such a manner that no damage occurs to the units during hauling, handling or unloading.
- 1.8.2 Temporary covers shall be provided. Precast concrete units shall be protected from staining.

PART 2 - PRODUCTS

- 2.1 Prior to installation, the manufacturer of precast concrete units shall obtain a compliance certificate by submitting two samples of each of the product type to the Province's Representative together with manufacturer's specifications, instructions and tests.
- 2.2 All samples submitted for approval shall be labeled with full information on materials, admixes, fabrication and finish methods. Approval samples shall be stamped, and identical samples retained at the Site and by the fabricator.
- 2.3 **Materials**
- 2.3.1 Precast concrete products shall be of sizes and finishes shown on the Definitive and Descriptive Drawings.
- 2.3.2 Cementitious materials shall conform to the following applicable CSA Specifications:
 - 2.3.2.1 General: Precast Concrete Units CSA-A23.4.
 - 2.3.2.2 Portland Cement: CAN/CSA-A5, Type 10 or Type 30.
 - 2.3.2.3 Hydrated Lime: Type S CSA A82.46; and
 - 2.3.2.4 Pozzolans: CSA-A23.4.
- 2.3.3 Aggregates shall be normal weight to conform to CSA-A23.I, except that grading requirements shall not necessarily apply.
- 2.3.4 Other constituents such as air-entraining agents, colouring pigments, integral water repellents, finely ground silica and similar materials shall be previously established as suitable for use in concrete and either shall conform to CSA Standards where applicable, or shall be shown by test or experience not to be detrimental to the concrete.

- 2.3.5 The same brands and source of cement, aggregate and other constituents shall be used for the entire Work to ensure uniformity of colouration and other mix characteristics.
- 2.3.6 Shims shall be lead or plastic, conforming to manufacturers recommendations.
- 2.3.7 Surface hardener for application to steps and landings shall be a non-metallic type conforming to hardener manufacturer's recommendations.
- 2.3.8 Reinforcement, accessory and connection materials shall be provided.

2.4 **Concrete Mix**

- 2.4.1 Portland Cement: shall conform to CAN/CSA-A5 Type 10 (normal).
- 2.4.2 Aggregate: shall conform to CSA-A23-1.
 - 2.4.2.1 Fine aggregate: locally available natural sands.
 - 2.4.2.2 Coarse aggregate: grey granite, gradation to match sample available for viewing at location designated by the Province's Representative.
- 2.4.3 Admixtures/mix proportions/air content shall be In accordance with Section 03345, "Concrete Finishing".
- 2.4.4 Mixes shall be prepared for each type of concrete and shall be proportional either by laboratory trial batch or field experience methods, complying with CSA-A23.4.
- 2.4.5 Mix design shall produce a compressive strength of 35 MPa at 28 Days.

2.5 **Mortar Mix**

- 2.5.1 For precast concrete units setting mortar bed use type M mortar based on proportion specifications of CSA A 179-M.

2.6 **Reinforcement, Anchors, and Steel Inserts**

- 2.6.1 The Primary Contractor shall design and attach anchors and inserts to precast concrete units to carry design loads.
- 2.6.2 Anchors and steel inserts shall be galvanized after fabrication.

2.7 **Manufacturing**

- 2.7.1 Each precast unit shall be marked to correspond to identification mark on the drawings for location at the Site.
- 2.7.2 Each precast unit shall be marked with date cast.

- 2.7.3 Markings shall be located on the unexposed faces of units.
- 2.7.4 Finished units shall be straight, true to size and shape, and within the specified casting tolerances.
- 2.7.5 Exposed edges shall be sharp, straight, and square; and all flat surfaces shall be in a true plane.
- 2.7.6 Warped, cracked, broken, spalled, stained, and otherwise defective units will not be acceptable.
- 2.7.7 All anchors, clips, inserts, reglets, lifting devices, stud bolts, shear ties, and other devices required for handling and installing the precast units, and for attachment of subsequent items shall be placed and secured in the forms.
- 2.7.8 Curing: the Work of this Section shall be form cured for a minimum of 20 hours. Products shall be kept wet continuously for not less than six days after being removed from the forms. Following this curing period, the units shall be allowed to air dry for at least four days before being erected.
- 2.7.9 Casting tolerances: casting, bowing, warping, and dimension tolerances shall be within the following limits:
- 2.7.9.1 overall dimension for height and width of units shall be plus zero of unit dimension to minimum 2.50 mm for three metres and more;
 - 2.7.9.2 thickness of units shall be plus or minus 3.00 mm maximum;
 - 2.7.9.3 bowing or warping shall not exceed 1/360 of the span;
 - 2.7.9.4 insert locations shall be within plus or minus 6.50 mm in each direction; and
 - 2.7.9.5 opening dimensions to figured dimensions shall be within a tolerance of plus 3.00 mm to minus zero.
- 2.8 **Finishes**
- 2.8.1 Finish for treads, landings, thresholds and safety edges shall be obtained by grinding the as-cast face to a smooth honed finish followed by a brush sandblasting to remove sheen from matrix. Sandblasting shall be in accordance with Section 03353, "Sandblasted Concrete Finish".
- 2.8.2 Tread and landing surfaces shall be slip-resistant and uniform in colour and material over the full width and depth except for the contrasting nosing strip. Tread and landing surfaces shall contrast with surrounding floor surfaces. See the Definitive and Descriptive Drawings in Appendix A to Schedule 4, the Construction Specifications

Section 09310 Ceramic Tile section in Appendix C of Schedule 4 and Article 10.9 [Materials and Finishes in Stations] for further information.

2.9 **Visual Inspection**

2.9.1 All precast units shall be sound and free of defects that would interfere with the proper installation of units or impair the strength or permanence of the construction.

PART 3 - EXECUTION

3.1 **Inspection**

3.1.1 The surfaces and areas affected by the Work of this Section shall be examined and conditions detrimental to correct installation shall be remedied. Installation shall not begin until the unsatisfactory conditions shall have been corrected.

3.1.2 The conditions and clearances required for setting of safety edges in particular the tolerance required at the track shall be verified.

3.2 **Installation of Treads**

3.2.1 Precast concrete units shall be installed straight, level and square and securely fastened in place

3.2.2 Units shall be laid in Type M mortar, with even joint depth of 15 mm. Joints shall be raked out and tooled to dense, smooth surface, 25 mm back from face of tread as indicated on the Drawings.

3.2.1 Apply 2 coats of penetrating silicone sealer over stair units after installation is complete and protect from traffic for 48 hours minimum.

3.3 **Adjust and Clean**

3.3.1 Units which have visual defects shall be repaired or replaced. Defective joints shall be re-pointed.

3.3.2 Soiled precast concrete surfaces shall be cleaned to the satisfaction of the Province's Representative.

3.3.3 The Primary Contractor shall remove all surplus material, rubbish and equipment from the Work Site.

END OF SECTION

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SECTION 04220

ARCHITECTURAL CONCRETE MASONRY UNIT

PART 1 - GENERAL

1.1 WORK INCLUDED

1.1.1 The Work shall include furnishing of all labour, material and equipment required for concrete masonry unit including but not limited to the following:

1.1.1.1 Reinforcement in concrete masonry unit walls;

1.1.1.2 Metal ties and anchors securing concrete masonry unit to structure, including drilling and grouting of dowels into concrete slabs and structural steel braces, connectors and anchors where required;

1.1.1.3 Mortar and concrete grout in concrete masonry unit cells containing reinforcing steel;

1.1.1.4 Building in and forming of openings for mechanical and electrical items within and passing through concrete masonry unit walls;

1.1.1.5 Building in of door and window frames and grouting as required;

1.1.1.6 Building in and grouting of insert and attachment devices;

1.1.1.7 Building in of access panels, miscellaneous metals, loose lintels, bearing plates, sleeves, anchor bolts, anchors and other similar items; and

1.1.1.8 Cleaning down of all concrete masonry unit.

1.1.1.9 Sealing of all concrete masonry units where specified

1.2 REFERENCES

1.2.1 CSA CAN3-A5: "Portland Cement".

1.2.2 CSA CAN3-A8: "Masonry Cement".

1.2.3 CSA A165.1: "Concrete Masonry Units".

1.2.4 CSA A179: "Mortar and Grout for Unit Masonry".

1.2.5 CSA A371: "Masonry Construction for Buildings".

1.2.6 CSA CAN3-S304: "Masonry Design and Construction for Buildings".

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- 1.2.7 ASTM C404-76: "Aggregates for Masonry Grout".
- 1.2.8 ASTM C-90: "Standard Specification for Load-Bearing Concrete Masonry Units".
- 1.2.9 TransLink Building Code Criteria and British Columbia Building Code.
- 1.3 SUBMITTALS
 - 1.3.1 The Primary Contractor will retain the review records for the following submittals and make them available on request, to the Province's Representative. Submittals will include:
 - 1.3.1.1 Certificate attesting to the qualification of concrete masonry units, mortar and/or grout;
 - 1.3.1.2 Mortar and grout mixes
 - 1.3.1.3 Mill certificates for reinforcing steel; and
 - 1.3.1.4 Four clearly labeled samples of masonry materials and accessories;
 - 1.3.2 Materials and finishes in the Work shall be equal to reviewed samples in all respects.
 - 1.3.2.1
- 1.4 QUALITY ASSURANCE
 - 1.4.1 The Work shall be carried out by skilled masons experienced in the installation of the products specified and the type of work to be undertaken.
 - 1.4.2 A mock-up panel of a minimum of 800 mm x 1200 mm shall be constructed at a location directed by the Province's Representative.
 - 1.4.3 The mock-up panel, when accepted by the Province's Representative, shall form a permanent part of the Work and will be representative of masonry placement, jointing, alignment and overall quality of erection.
 - 1.4.4 The Primary Contractor shall arrange and pay for masonry unit and mortar cube strength tests in the plant that shall be carried out by an independent testing agency per Section 01400 "Quality Requirements"
 - 1.4.5 The following will be considered as defects:
 - 1.4.5.1 Shrinkage, spalling, chipping and or cracking in individual units and erected work;
 - 1.4.5.2 Walls or individual units out of alignment or out of plumb and irregularities in vertical and/or horizontal courses and/or joint widths;

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- 1.4.5.3 Poor colour or texture blending of units;
- 1.4.5.4 Failure of built-in items to remain anchored and/or wall bracing or anchorage to the building structure; and
- 1.4.5.5 Discoloration, crumbling, and similar deterioration of mortar
- 1.4.5.6 Poor mortar and grout workmanship such as too little or excessive material, voids, poorly tooled joints, splatter and overspill left on concrete masonry unit exposed surfaces

1.5 DELIVERY, STORAGE AND HANDLING

- 1.5.1 Concrete masonry units and cementitious material shall be delivered to the Work Site in manufacturer's original protective wrappings with labels intact, in a clean and dry condition.
- 1.5.2 All material shall be stored on pallets or platforms under waterproof cover, clear of ground contact.
- 1.5.3 Stacking and handling of concrete masonry units shall be in a manner to prevent chipping and cracking of units.

1.6 ENVIRONMENTAL REQUIREMENTS

- 1.6.1 Cold weather construction requirements shall be in accordance with CSA A371:
 - 1.6.1.1 Materials and surrounding air temperature shall be maintained to minimum 10 degrees Celsius prior to, during, and for a minimum of 48 hours after completion of masonry work; and
 - 1.6.1.2 During freezing or near freezing weather adequate equipment or cover shall be provided to maintain a minimum temperature of 10 degrees Celsius, and to protect the masonry work completed or in progress.

PART 2 - PRODUCTS

2.1 MATERIALS

- 2.1.1 Concrete masonry unit:
 - 2.1.1.1 Concrete masonry unit components shall be in accordance with CSA A165.1 for manufacturing tolerances, mix content, appearance and format;
 - 2.1.1.2 Concrete masonry unit type shall be H/7.5/A/M for normal weight masonry in accordance with Table 1 of CSA A165.1;

- 2.1.1.3 The minimum compressive strength of concrete masonry units shall be 15 MPa calculated on the net area, based on an average of five units;
 - 2.1.1.4 The size of concrete masonry units shall be actual face dimensions 190 mm high by 390 mm long by nominal widths scheduled;
 - 2.1.1.5 Exposed Faces: Ground face at all Stations and Propulsion Power Substations (PPS) located at Stations. A combination of ground face and split face is acceptable at remote PPS locations .
 - 2.1.1.6 Special concrete masonry units required to complete the Work shall be provided, including lintel, bond beam, finished end, intersection, control joint and end units; and
 - 2.1.1.7 Concrete masonry unit items shall be from the same manufacturer and all units used at each individual Station and Other Fixed Facility site shall be from the same production run to ensure uniformity of texture and colour.
- 2.1.2 Joint Reinforcement:
- 2.1.2.1 In the absence of any other structural and seismic requirements, minimum joint reinforcement, where indicated, shall be horizontal ladder type reinforcing composed of two parallel 4.8 mm diameter steel side rods Joined together by 4.8 mm diameter steel cross rods spaced at 400 mm on centre and welded in place and shall conform to CSA G30.3; However the Structural Engineer of record shall be responsible to specify the type, gage and spacing of all horizontal and other steel reinforcement for all concrete masonry unit walls.
 - 2.1.2.2 All joint reinforcement material shall be hot dipped galvanized after welding fabrication;
 - 2.1.2.3 The widths of joint reinforcing shall be 50 mm less than the width of the masonry unit; and
 - 2.1.2.4 Cross rods shall be formed with drips where reinforcing is applicable to exterior walls and without drips where applicable to interior walls.
- 2.1.3 Ties and Anchors:
- 2.1.3.1 Ties and anchors shall be hot dipped galvanized steel rod or sheet steel configurations, adjustable to engage block coursing; and
 - 2.1.3.2 Ties and anchors shall be suitable for attachment to structural back-up and shall conform to CSA CAN3-S304.
- 2.1.4 Reinforcing steel shall conform to CSA-G30.12 grade 400.

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2.1.5 Grout Materials:

2.1.5.1 Portland cement shall conform with CSA CAN3-A5; and

2.1.5.2 Aggregates for masonry grout shall be 10 mm maximum size and shall conform to ASTM C404.

2.1.6 Water shall be potable.

2.1.7 Sand for masonry mortar shall consist of fine granulated material composed of hard, strong, durable mineral particles and free of saline, alkaline, organic or other harmful materials. It shall conform to CSA A82.56.

2.2 MIXES

2.2.1 Mortar:

2.2.1.1 Mortar except as noted shall be Type S conforming to CSA A179. Masonry cement shall be used in preference to Portland cement and lime.

2.2.2 Concrete Grout:

2.2.2.1 Concrete grout strength shall be 15 MPa at 28 Days and shall conform to CSA A179; and

2.2.2.2 Grout shall be of fluid consistency with a slump of 200 mm to 250 mm.

PART 3 - EXECUTION

3.1 TOLERANCES

3.1.1 Tolerances shall be in accordance with CSA A371 and as follows:

3.1.1.1 Variation from Mean Plane: 6 mm when measured with a 3m straight edge.

3.1.1.2 Variation from Plumb: 3 mm on any vertical line up to 3m high.

3.1.1.3 Variation in Sizes of Wall Openings: 6 mm maximum.

3.1.1.4 Variation from Grade Levels Stated: 6 mm.

3.2 BOND

3.2.1 Concrete masonry unit shall be running bond unless indicated otherwise.

3.3 JOINT SIZES AND PROFILES

3.3.1 Exposed Interior Masonry Joints: Uniform 10 mm width, struck flush.

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3.3.2 Exposed Exterior Masonry Joints: Uniform 10 mm width, concave-tooled.

3.3.3 Concealed Masonry Joints: Uniform 10 mm width, struck flush.

END OF SECTION 04220

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SECTION 09305
PLATFORM EDGE

PART 1 - GENERAL

1.1 SUMMARY

1.1.1 This Section specifies furnishing and installing station platform edges composed of modular paver, detectable warning surface tiles with reinforced epoxy polymer concrete core, with stainless steel fasteners, leveling screws, and accessories as indicated and specified for a complete system.

1.2 SUBMITTALS

The Primary Contractor will retain reviewed submittals and will make them available on request to the Province's Representative. Submittals will include the following:

1.2.1 Product Data: Manufacturer's literature describing products, installation and routine maintenance.

1.2.2 Samples for verification purposes: Three samples of a universally accessible surface applied tactile tile and surface applied detectable directional bar tiles of the kind proposed for use.

1.2.3 Shop drawings are required for products specified showing fabrication details; composite structural system; plans of tile placement including joints, and material to be used as well as outlining installation materials and procedure.

1.2.4 Material test report: Test reports from qualified independent testing laboratory indicating that materials are proposed for use are in compliance with requirements and meet the properties indicated. All test reports shall be conducted on a universally accessible surface applied tactile tile and surface applied detectable directional bar tiles as certified by a qualified independent testing laboratory.

1.2.5 Maintenance instructions: submit copies of manufacturer's specified maintenance practices for each type of tactile tiles.

1.3 QUALITY ASSURANCE

1.3.1 Provide surface applied tiles and accessories as produced by a single manufacturer.

1.3.2 Installer's qualifications: Engage an experienced installer certified in writing by tactile flooring manufacturer as qualified for installation, who has successfully completed tile installations similar in material, design, and extent to this Project.

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1.3.3 Pre-installation conference: Two weeks prior to start of installation the Primary Contractor shall convene a pre-installation conference. Attendees shall include the tile manufacturer's representative, field engineer, Primary Contractor, Province's Representative, and representative subcontractor for each related Section. Review the following:

1.3.3.1 Requirements for concrete substrate

1.3.3.2 Location of control joints

1.3.3.3 Coordination of reviewed shop drawings

1.3.4 Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and qualities of materials and execution.

1.3.4.1 Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.4 PERFORMANCE REQUIREMENTS

1.4.1.1 Water Absorption of Tile when tested by ASTM-D 570 not to exceed 0.35%.

1.4.1.2 Slip Resistance of Tile when tested by ASTM-C 1028 the combined wet/dry static co-efficient of friction not to be less than 0.80.

1.4.1.3 Compressive Strength of tile when tested by ASTM-D 695-91 not to be less than 18,000 psi.

1.4.1.4 Tensile Strength of Tile when tested by ASTM-D 638-91 not to be less than 10,000 psi.

1.4.1.5 Flexural Strength of Tile when tested by ASTM - C293-94 not to be less than 24,000 psi.

1.4.1.6 Gardner Impact to geometry "GE" of the standard when tested by ASTM-D 5420-93 to have a mean failure energy expressed as a function of specimen thickness of not less than 450 in. lbf/in. A failure is noted if a hairline fracture is visible in the specimen.

1.4.1.7 Chemical Stain Resistance of Tile when tested by ASTM-D 543-87 to withstand without discoloration or staining - 1% hydrochloric acid, urine, calcium chloride, stamp pad ink, gum and red aerosol paint.

1.4.1.8 Abrasive Wear of Tile when tested by BYK - Gardner Tester ASTM-D 2386* with reciprocating linear motion of $37 \pm$ cycles per minute over a 10" travel. The abrasive medium, 40 grit Norton Metallite sand paper, was fixed and leveled to a holder. The combined mass of the sled, weight and wood block is 3.2

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lb. Average wear depth shall not exceed 0.030 after 1000 abrasion cycles measured on the top surface of the dome representing the average of three measurement locations per sample.

1.4.1.9 Fire Resistance: When tested to ASTM E84 flame spread shall be less than 25.

1.4.1.10 Accelerated Weathering of Tile when tested by ASTM-G26-95 for 2000 hours shall exhibit the following result - no deterioration, fading or chalking of surface of tile.

1.4.2 Accelerated Weathering of Tile when tested by ASTM-G26-95 for 2000 hours shall exhibit the following result - no deterioration, fading or chalking of surface of tile.

1.4.2.1 Accelerated Aging and Freeze Thaw Test of Tile and Adhesive System when tested to ASTM-D 1037 shall show no evidence of cracking, delamination, warpage, checking, blistering, color change, loosening of tiles or other defects.

1.4.2.2 Salt and Spray Performance of Tile and Adhesive System when tested to ASTM-B 117 not to show any deterioration or other defects after 100 hours of exposure.

1.4.3 Vitrified Polymer Composite (VPC) surface applied concrete tactile tiles shall be an epoxy polymer composition with an ultra-violet coating employing aluminum oxide particles in the truncated domes.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Deliver tactile tiles and accessories to the Site in original, unopened package, identified by part number and stored in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

1.6 PROJECT CONDITIONS

1.6.1 Environmental conditions and protection: Maintain minimum temperature of 40 deg F (4.4 deg C) in spaces to receive tactile tiles for at least 48 hours prior to installations, during installation, and for not less than 48 hours after installation. Store tactile tiles material in spaces where they will be installed for at least 48 hours before beginning installation. Subsequently, maintain minimum temperature of 40 deg F (4.4 deg C) in areas where work is completed.

1.6.2 The use of water for work, cleaning or dust control, etc. shall be in contained and controlled and shall not be allowed to come into contact with the passengers or public. Provide barricades or screens to protect passengers or public.

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- 1.6.3 Disposal of any liquids or other materials of possible contamination shall be made in accordance with federal state and local laws and ordinances.
- 1.6.4 Cleaning materials shall have code acceptable low VOC solvent content and low flammability if used on the site.
- 1.6.5 Primary Contractor shall coordinate phasing and flagging personnel operations as specified elsewhere.
- 1.7 COORDINATION
 - 1.7.1 Coordinate layout and installation of tactile tiles with other construction
- 1.8 EXTRA MATERIALS
 - 1.8.1 Deliver extra stock to warehouse designated by engineer. Furnish new materials from same manufactured lot as materials installed and enclose in protective packaging with appropriate identification. Furnish not less than 2 % of the supplied materials for each type, color and pattern installed.
- 1.9 GUARANTEE
 - 1.9.1 Platform edge tiles shall be guaranteed in writing for five (5) years from date of Substantial Performance. The guarantee includes defective work, breakage, deformation, fading, and loosening of tiles

PART 2 - PRODUCTS

- 2.1 MANUFACTURERS
 - 2.1.1 In other Part 2 articles where titles below introduce lists, the following requirements apply for product selection:
 - 2.1.1.1 Products: Subject to compliance with requirements, provide the product specified, or approved substitution:
 - 2.1.1.1.1 Platform edge power tile: Vitrified Composite (VPC) modular paver detectable/tactile surface tile of epoxy polymer composition with ultra-violet protective coating, employing aluminum oxide particles in the truncated domes
 - 2.1.1.2 Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified or approved.
 - 2.1.2 Manufacturer of products for basis of Design.

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- 2.1.2.1 The Vitrified Polymer Composite (VPC) surface applied concrete tactile tiles specified is based on Armor-Tile manufactured by Engineered Plastics Inc.
- 2.1.3 Physical Properties:
 - 2.1.3.1 Dimensions: platform edge tiles shall be within the following dimensions and tolerances:
 - 2.1.3.1.1 Length and width: 498 mm x 619 mm (nominal) typical – note that the last 2500 mm of the platform ends are tapered
 - 2.1.3.1.2 Depth: 50 mm (+/-) 5% max
 - 2.1.3.1.3 Face thickness: 3.18 mm (+/-) 5% max
 - 2.1.3.1.4 Warpage of edge: 0.5% max
 - 2.1.3.2 Color: Yellow conforming to Federal Color No. 33538. Color shall be homogenous throughout the tile.
 - 2.1.3.3 Core materials: Platform edge tiles shall have a structural epoxy polymer concrete core and internal stainless steel system as installed by the manufacturer.
 - 2.1.3.4 Threaded holes: ensure that threaded holes are sized and finished to accommodate set screws
- 2.2 MATERIALS
 - 2.2.1 Stainless steel low profile expansion anchors 6mm diameter by 54mm long to be positioned in the molded recess of fourteen truncated domes per tile minimum.
 - 2.2.2 Sealants: Ensure that sealant is compatible with substrates.
 - 2.2.2.1 Between platform edge tiles: Polyurethane elastomeric sealant.

Acceptable product: Sika 2c NS/SL or other sealant approved by platform edge tile manufacturer
 - 2.2.2.2 Between platform edge tile and platform edge angle: Hybrid epoxy/urethane sealant.

Acceptable product: Hilti CS300 EP or other sealant approved by platform edge tile manufacturer
 - 2.2.3 Angle edge gasket: 3mm thick by angle width, continuous closed cell neoprene gasket for top of edge angle to accommodate uneven finish to underside of platform edge tiles

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2.2.4 Washers: Provide manufacturer recommended washers and other accessories for a complete installation.

2.2.5 Perimeter control joints: Schluter Dilex KSA or approved equal

PART 3 - EXECUTION

3.1 EXAMINATION

3.1.1 Examine areas to receive platform edge with installer present. Correct unsatisfactory conditions. Start of work indicates acceptance of conditions.

3.1.2 Throughout the installation phases of surface preparation and tile setting, ensure that care is taken to prevent damage to any work.

3.2 PREPARATION

3.2.1 Protect panels against damage during construction period to comply with tactile panel manufacturer's specification.

3.2.2 Protect panels against damage from rolling loads following installation by covering with plywood or hardwood.

3.2.3 Clean tactile panels not more than four days prior to date scheduled for inspection intended to establish date of substantial completion in each area of project. Clean tactile panel by method specified by tactile panel manufacturer.

3.3 INSTALLATION – PLATFORM EDGE TILE

3.3.1 Install platform edge tiles in accordance with manufacturer's recommended instructions, installation procedures, and shop drawings.

3.3.2 Install neoprene gasket on angle edge and cut holes for bolts.

3.3.3 Place and adjust platform edge tiles using stainless steel leveling screws and stainless steel fasteners.

3.3.4 Use an electronic level to check that required slope is achieved and that tile is positioned within allowable tolerances. Place platform edge tiles true and square to platform edge.

END OF SECTION 09305

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SECTION 09310

TILING

PART 1 - GENERAL

1.1 WORK INCLUDED

- 1.1.1 The Work includes furnishing of all necessary labour, material and equipment required for the supply and installation of ceramic tiles and related accessories.
- 1.1.2 Provide porcelain floor tile with accessories for a complete installation as indicated and specified.
- 1.1.3 Provide bonded thick mud bed sloped to drain over structural slab application as indicated.
- 1.1.4 Provide waterproofing and crack suppression individual and combination membranes as specified.
- 1.1.5 Provide thin set floor, coved wall base and trim tile application as indicated.
- 1.1.6 Related Documents: Definitive and Descriptive Drawings

1.2 QUALITY CONTROL

- 1.2.1 Ceramic tile Work shall be performed by Primary Contractor employing trained personnel with a minimum two years proven experience.
- 1.2.2 The manufacturer and the applicator shall be listed or approved by the Ceramic Tile Contractor's Association of British Columbia (CTCABC).
- 1.2.3 Perform work in accordance with Section 01400 Quality Requirements

1.3 REFERENCES

- 1.3.1 The latest publically available versions of the following references shall apply unless otherwise noted.
- 1.3.2 Specification Guide 09 30 00 Tile Installation Manual, Terrazzo, Tile, and Marble Association of Canada (TTMAC).
- 1.3.3 Terrazzo, Tile, and Marble Association of Canada latest Maintenance Guide
- 1.3.4 Tile Council of North America (TCNA) TCA Handbook for Ceramic Tile Installation
- 1.3.5 American National Standards for the Installation of Ceramic Tile ANSI A108/A118/A136.1 Specifications for the Installation of Ceramic Tile - Version 2010.1 and ANSI A137.1 Specifications for Ceramic Tile
- 1.3.6 Various applicable ASTM International Standard Test Methods noted in these reference materials and this specification section.

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- 1.3.7 Porcelain Tile Certification Agency (PTCA) for Porcelain Tile
 - 1.3.8 CAN/CSA-A5: "Portland Cement".
 - 1.3.9 CAN/CGSB-75.1-M88: Tile, Ceramic.
 - 1.3.10 ASTM A 185 Specification for Steel Welded Wire, Fabric, Plain for Concrete Reinforcement
 - 1.3.11 ASTM A82/A82M-05a Standard Specification for Steel Wire, Plain for Concrete Reinforcement
 - 1.3.12 ASTM A641/A641M-03 Standard Specification for Zinc Coated (Galvanized) Carbon Steel Wire
 - 1.3.13 ASTM C 33 Concrete Aggregates
 - 1.3.14 ASTM C144-04 Masonry Aggregates
 - 1.3.15 ASTM C 144 Portland Cement
 - 1.3.16 ASTM C373-88 Standard Test Method for Water Absorption, Bulk Density, Apparent Porosity and Apparent Specific Bravity of Fired Whiteware Products
 - 1.3.17 ASTM C627-93 Standard Method for Evaluating Ceramic Floor Tile Installation Systems
 - 1.3.18 ASTM C648-04 Standard Test Method for Breaking Strength of Ceramic Tile
 - 1.3.19 ASTM C241-90 Abrasion Resistance
 - 1.3.20 ASTM 1597M-04 Standard Specification for Gypsum Wallboard (Hard Metric Sizes)
 - 1.3.21 ASTM C1028-06 Standard Test Method for Evaluating the Static Coefficient of Friction of Ceramic Tile
 - 1.3.22 ASTM C1178/C1178M-04e1 Standard Specification for Glass Mat Water-Resistant Gypsum Backing Panel
 - 1.3.23 ANSI A118.1 Dry-Set Portland Cement
 - 1.3.24 Slurry Bond Coat: ANSI 118.4 and 118.11 A-C
 - 1.3.25 Bond Coat or Thin Set Medium Bed Latex-Portland Cement Mortar: ANSI 118.4 and 118.11
 - 1.3.26 Waterproof Membrane: ANSI 118.10
 - 1.3.27 Crack Isolation Membrane: ANSI 118.12
 - 1.3.28 Waterproof and Crack Isolation Combination Membrane – Load Bearing and Bonding: ANSI 118.10 and ANSI 118.12
 - 1.3.29 Polymer Modified Cement Based Premium Grout: ANSI 118.7

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1.3.30 Epoxy Grout – Water Cleanable (if required for specific applications): ANSI 118.3

1.3.31 Epoxy Grout (if required for specific applications): ANSI 118.8

1.3.32 Cementitious Backer Units ANSI A118.9

1.3.33 CAN/CGSB-25.20-95 Surface Sealer for Floors

1.3.34 CAN/CGSB-51.34-M86 Vapour Barrier, Polyethylene Film for Use in Building Construction

1.3.35 CAN/CGSB-75.1-M88 Tile, Ceramic

1.4 PERFORMANCE REQUIREMENTS

1.4.1 Static Coefficient of Friction: For tile installed on walkway surfaces, provide products with the following values as determined by testing identical products per ASTM C1028:

Note: The tile as well as the total assembly must be able to meet or surpass the testing requirements under conditions similar to actual transit station usage and environments.

1.4.1.1 Level Surfaces Dry Areas: Minimum 0.6.

1.4.1.2 Level Surfaces Wet Areas or Areas that could become wet or damp: Minimum 0.7

1.4.1.3 Step Treads: Minimum 0.8

1.4.1.4 Ramp Surfaces: Minimum 0.8.

1.4.1.5 Sloped Floors: Minimum 0.8

1.4.2 Traffic Level Performance: Floor tiles to meet Extra Heavy traffic level performance passing ASTM C627 cycles 1 through 14 as described in TTMAC Tile Specification Guide 09 30 00.

1.4.3 All Porcelain Tiles provided for Work in this Section to be frost resistant in accordance with CAN/CGSB 75.1 and shall have a moisture absorption rating of 3% or less.

1.5 SUBMITTALS

1.5.1 Product Data: Include installation and maintenance instructions for each type of product specified and each product to be used.

1.5.2 The Primary Contractor shall provide independent laboratory test results verifying slip resistance criteria for floor tiles to ASTM C1028-07. Acceptable criteria as noted in section 1.4.1 above or better.

1.5.3 The Primary Contractor shall provide data for the maintenance of ceramic tiles, to be included in maintenance manuals.

1.5.4 Shop Drawings:

1.5.4.1 Show locations of each type of tile and tile pattern.

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- 1.5.4.2 Show widths, details, and locations of expansion, contraction, control, and isolation joints in tile substrates and finished tile surfaces.
- 1.5.5 Samples for Verification:
- 1.5.5.1 Assembled samples with grouted joints for each colour, texture, size and pattern of tile being set, at least 800 mm square and mounted on rigid panel, complete with grout of type and in colour(s) that once approved for completed work shall be used as the performance standard.
- 1.5.5.2 Submittals shall clearly indicate materials, colour(s), thicknesses, finishes, joints, pattern details and accessories.
- 1.5.5.3 Full-size units for each type of trim and accessory
- 1.5.5.4 Metal edge strips in 150 mm (6 inches) lengths.
- 1.5.5.5 Submit samples a minimum of six weeks before scheduled start of installation.
- 1.5.5.6 Approved sample panels shall be retained and protected at the work site and will form the standard for acceptable work depicting the minimum level of craftsmanship to be provided and shall be used as a quality control sample for the project. Premium materials and high levels of craftsmanship are expected commensurate with the high visibility and heavy use of these transit stations.
- 1.5.6 Product Certificates: For each type of product, signed by product manufacturer.
- 1.5.7 Qualification Data: Installer to submit a listing of at least three previously completed projects of similar size and scope.
- 1.5.8 Maintenance Data: The Primary Contractor shall provide data for all products used and all maintenance requirements and manufacturers recommendations for each different ceramic tile installation and include this data in the maintenance manuals along with latest TTMAC Maintenance Guide. Give specific warning of any maintenance practice or materials that may damage or disfigure the finished work. Include WHMIS and MSDS product data sheets for floor sealer products.
- 1.5.9 If and when more than one manufacturer's products are part of a single tile assembly, arrange for each manufacturer to submit a written statement of compatibility with respect to the other specific manufacturer's materials being used. Do not use any materials that cannot be formally verified for compatibility and full specified performance and warranties of the tile assembly system.
- 1.5.10 The Primary Contractor will retain the review records for the submittals and make them available on request, to the Province's Representative.
- 1.6 QUALITY ASSURANCE
- 1.6.1 Installer: Employ skilled mechanics trained and experienced the tile work, company must be registered as members in good standing with the Terrazzo, Tile, and Marble Association of Canada (TTMAC) with a minimum of 2 years proven experience.

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- 1.6.2 Supplier to be a member in good standing with the Terrazzo, Tile, and Marble Association of Canada, providing materials meeting the minimum standards of TTMAC.
- 1.6.3 Source limitations for tile: Obtain tile of same type and colour or finish from one source or producer. Obtain tile from same production run and of consistent quality in appearance and physical properties for each contiguous area.
- 1.6.4 Source limitations for setting and grouting materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from a single manufacturer and each aggregate from one source or producer. Obtain integral coloured grout and joint sealant from same production run and of consistent quality in appearance and physical properties for each contiguous area.
- 1.6.5 Source limitations for other products: Obtain each of the following products specified in this Section through one source from a single manufacturer for each product:
- 1.6.5.1 Pre-manufactured metal edge strips, control joints and any other tile setting accessories used on the project
 - 1.6.5.2 All tile setting and grouting materials including slurry coat, mud bed, waterproofing & crack-suppression membrane(s), thin set mortar and grout.
 - 1.6.5.3 Sealants if used
- 1.6.6 Mock-ups:
- 1.6.6.1 Build mock-up of 3 square meters (100sf) of each type of tile installation to verify selections and to demonstrate aesthetic effects and qualities of materials and execution. Mockups for infill strips at walker ducts may be reduced to 1 square metre.
 - 1.6.6.2 Incorporate edge strips and sealants into mock ups.
 - 1.6.6.3 Build mock-up of floor tile installations.
 - 1.6.6.4 Build mock-up of wall tile installations.
 - 1.6.6.5 Approved mock-ups may become part of the completed Work if undisturbed at time of Substantial Performance.
- 1.7 PRE-INSTALLATION CONFERENCE
- 1.7.1 Pre-installation conference: Two weeks prior to start of installation the Primary Contractor shall convene a pre-installation conference. Attendees shall include the tile manufacturer's representative, field engineer, Primary Contractor, Province's Representative, and representative subcontractor for each related Section.
- 1.8 SPARE MATERIALS
- 1.8.1 Furnish spare materials described below that match products procured and installed as part of the original material order from the same production run.

STRICTLY CONFIDENTIAL

- 1.8.2 Supply additional material of each type, colour and pattern of installed tile as follows:
- 1.8.2.1 For porcelain tile and trim units 300 mm x 300 mm provide a minimum of 4% of each additional unit.
 - 1.8.2.2 For porcelain tile and trim units 300 mm x 600 mm provide a minimum of 4% of each additional unit.
- 1.8.3 Neatly package in unopened original containers, with protective covering to prevent damage for storage and identify with labels describing contents, manufacturer, product names, colour and pattern. Deliver to the Province in accordance with the requirements set out in Article 3.6.1 [Station Spare Parts], Part 3 of this Schedule.
- 1.9 DELIVERY, STORAGE, AND HANDLING
- 1.9.1 Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. Comply with requirement in ANSI A137.1 for labeling sealed tile packages.
 - 1.9.2 Store tile, related materials and cementitious materials on dry surfaces elevated as required to protect them from ground water, under cover, and in a dry location protected from freezing, staining and damage.
 - 1.9.3 Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
 - 1.9.4 Store liquid latexes in unopened containers and protected from freezing.

PART 2 - PRODUCTS

- 2.1 PORCELAIN TILE UNGLAZED (floor application):
- 2.1.1 Approved manufacturers:
 - 2.1.1.1 Ames Tile & Stone
 - 2.1.1.2 Royal Mosa
 - 2.1.1.3 Casalgrande
 - 2.1.1.4 Cercom
 - 2.1.1.5 Product of approved equal
 - 2.1.2 Composition: Porcelain
 - 2.1.3 Surface: Slip resistant texture that is easily cleanable
 - 2.1.4 Module Size: For main station space 300 mm x 300 mm and 300 mm x 600mm unless otherwise noted on the drawings. For bathroom and ancillary space module size 25 mm x 25 mm or 50 mm x 50 mm unless otherwise noted.

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- 2.1.5 Nominal Thickness: 8mm
- 2.1.6 Color and Pattern: Solid color through entire body of tile as selected by the Province's Representative from the approved manufacturer's latest standard colour / pattern range for the tile specified.
- 2.1.7 Bases shall be at least 100 mm. high nominally, unglazed, non-slip, to match floor tile, composed of matching porcelain tile, cove, corner, and bullnose fittings as required to trim at walls, and other like terminations.
- 2.2 CERAMIC TILE GLAZED OR UNGLAZED (wall application):
- 2.2.1 Approved manufacture:
- 2.2.1.1 Ames Tile & Stone
 - 2.2.1.2 Casalgrande
 - 2.2.1.3 Cercom
 - 2.2.1.4 Royal Mosa
 - 2.2.1.5 Product of approved equal
- 2.2.2 Composition: Impervious natural clay or Porcelain
- 2.2.3 Surface: Smooth plain or textured determined by aesthetic reasons
- 2.2.4 Nominal Thickness: 8mm
- 2.2.5 Color and Pattern: as selected by the Province's Representative from the approved manufacturer's latest standard colour / pattern range for the tile specified.
- 2.3 TACTILE WAYFINDING TILE FOR VISUALLY IMPAIRED PERSONS
- 2.3.1 Tactile Warning Strip for Visually Impaired: 200 mm x 200 mm x 8mm minimum, unglazed porcelain with raised profile, textured finish:
- 2.3.1.1 Manufacturer / Series / Finish
 - 2.3.1.1.1 Ames / Antisddrucciolo / P
 - 2.3.1.1.2 Cercom / Euro Proflio / Fluorite
 - 2.3.1.1.3 Casalgrande / Technic / Bugnato
- 2.3.2 Wayfinding for Visually Impaired: 300 mm x 300mm, with raised profile, textured finish:
- 2.3.2.1 Manufacturer / Series/Product Code:

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- 2.3.2.2 Royal Mosa / Global Collection/accessories BG
- 2.3.3 Composition: Impervious natural clay or Porcelain Unglazed
- 2.3.4 Color and Pattern: as selected by the Province's Representative from the approved manufacturer's latest standard colour / pattern range for the tile specified.
- 2.4 SETTING AND GROUTING MATERIALS
- 2.4.1 Setting and grouting mixtures shall be provided in accordance with TTMAC, Tile Installation Manual, for the particular system specified in accordance with approved tile manufacturer's latest printed directions unless otherwise shown. Colour shall be selected to match and compliment selected tile color as closely as possible by consideration of various approved available manufacturers standard colours as selected by the Province's Representative.
- 2.4.2 Setting bed for wall and floor porcelain tile shall be two component non-flammable, non-toxic, latex or acrylic reinforced thin-set mortar system undiluted and factory prepared. Companion joint grouting materials shall be used and colour shall be as selected by the Province's Representative.
- 2.4.3 Use high quality tile accessories at major horizontal and vertical corner joints and expansion joints in lieu of grout or sealant as well as other locations where high probably of grout joints cracking due to movement exists such as manufactured by Schluter Systems.
- 2.4.4 Subject to compliance with specifications the following manufacturers are acceptable for setting and grouting materials. Use products to provide a complete tile setting system from a single manufacturer eligible for manufacturers most extensive warranty program.
- 2.4.5 Manufacturers:
- 2.4.5.1 Custom Building Products of Canada Ltd.
 - 2.4.5.2 LATICRETE International Inc.
 - 2.4.5.3 MAPEI Corporation
 - 2.4.5.4 Balco Inc for expansion joints and covers
 - 2.4.5.5 Schluter Systems for termination, transition and control joint trims
 - 2.4.5.6 Or approved alternative.
- 2.4.6 Water: All water used for the preparation of all applicable tile assembly materials shall be potable, clean and free of chemicals and contaminants detrimental to mortar or grout mixes.
- 2.5 TYPICAL FLOOR TILE THICK SET APPLICATIONS
- 2.5.1 Slurry Thick Mortar Bed Bond Coat

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- 2.5.1.1 Slurry bond coat to bond thick mud bed over new and existing structural concrete slabs – acceptable products:
 - 2.5.1.1.1 Custom Building Products: MegaFlex Thin-set Grey
 - 2.5.1.1.2 Mapei: Planicrete AC acrylic latex admixture mixed with Portland cement and dry sand.
 - 2.5.1.1.3 Laticrete: 4237 Latex Additive with 211 Powder **or** 254 Platinum thin bed mortar
- 2.5.2 Thick Mortar Bed Sloped to Floor Drains
 - 2.5.2.1 Portland cement mortar (thick set) installation materials: Conforming to ANSI A108.1A and as specified below:
 - 2.5.2.1.1 Latex additive: Manufacturer's standard water emulsion, serving as replacement for part or all of water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed.
 - 2.5.2.1.2 Welded wire reinforcement mesh: 51 mm x 51 mm mesh size, fabricated from 1.6 mm thick galvanized steel wire; welded fabric design
 - 2.5.2.1.3 Acceptable Products:
 - 2.5.2.1.3.1 Custom Building Products: Thick bed bedding mortar 3:1 sand/cement mixed with 1 part Custom Building Products Patching and Leveling Latex Additive to 2 parts water
 - 2.5.2.1.3.2 Mapei Topcem Premix accelerated cure mortar with Planicrete AC acrylic latex admixture for accelerated installation time sensitive applications.
 - 2.5.2.1.3.3 Mapei 4 to 1 Mud Bed Mix with Planicrete AC acrylic latex admixture for conventional curing time applications.
 - 2.5.2.1.3.4 Laticrete 226 Thick Bed Mortar with Laticrete3701 Latex Mortar Admixture or Laticrete 3701 Fortified Mortar Bed.
 - 2.5.2.1.3.5 4:1 sand / cement (Type 10 Portland) with Acrylic Admixture and Patching and Levelling Additive. See Section 2.13 Mixing Mortars and Grout for further information and requirements.
- 2.5.3 Waterproofing & Crack Suppression Membranes
 - 2.5.3.1 Combination waterproofing and anti-fracture membrane: Liquid latex rubber and fabric reinforcement conforming to ASTM C 627 rated for extra heavy service. Acceptable products:

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- 2.5.3.1.1 Custom Building Products: RedGard with Fabric Reinforcement at cracks or Custom 9240 Fabric Reinforced System Waterproofing and Anti-Fracture Membrane
- 2.5.3.1.2 Mapei Mapelastic 315 (two-coat system and mesh) used with Mapei Fiberglass Mesh embedded in membrane and Mapei Mapeband rubber coated waterproofing strips embedded in membrane at all expansion and construction joints and vertical wall or other transitions where subject to movement.
- 2.5.3.1.3 Laticrete: Hydro Ban with Fabric Reinforcement at cracks **or** 9325 Fabric Reinforced System Waterproof Membrane
- 2.5.3.1.4 Or approved alternative.
 - 2.5.3.1.4.1 Self-levelling coat: As recommended by membrane manufacturer.
 - 2.5.3.1.4.2 Primer: As recommended by membrane manufacturer.
- 2.5.3.2 Waterproofing Membrane (without Anti-Fracture requirement):
 - 2.5.3.2.1 Custom Building Products: RedGard with Fabric Reinforcement at cracks or Custom 9240 Fabric Reinforced System Waterproofing Membrane
 - 2.5.3.2.2 Mapei Mapelastic 315 (two-coat system) with Fabric Reinforcement at cracks
 - 2.5.3.2.3 Laticrete: Hydro Ban with Fabric Reinforcement at cracks **or** 9325 Fabric Reinforced System Waterproof Membrane
- 2.5.3.3 Anti-Fracture Membrane (without waterproofing requirement): peel and stick or liquid and fabric reinforcement conforming to ASTM C 627 rated for extra heavy service. Acceptable products:
 - 2.5.3.3.1 Custom Building Products: Crack Buster Pro Crack Prevention Mat Underlayment with Custom Building Products Peel and Stick Primer
 - 2.5.3.3.2 Mapei Mapeguard 2 peel and stick crack isolation membrane over Mapei SM Primer applied to concrete slab.
 - 2.5.3.3.3 Laticrete: Blue 92 Anti-Fracture Membrane with Reinforcing Fabric System
- 2.5.4 Thin Set Tile Bonding Mortar
 - 2.5.4.1 Floors: Chemical-Resistant, Water-Cleanable, Tile Setting and Grouting: Conforming to ANSI A118.4. Acceptable products:

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- 2.5.4.1.1 Custom Building Products:
 - 2.5.4.1.1.1 Standard Floor Setting: MegaFlex Crack Prevention Thin-set Grey or White when required
 - 2.5.4.1.1.2 Standard Wall Setting: MegaLite Crack Prevention Thin-set Grey or White when required
 - 2.5.4.1.1.3 Fast Setting: MegaLite Rapid Setting Crack Prevention Mortar Grey or White when required
- 2.5.4.1.2 Mapei:
 - 2.5.4.1.2.1 Granirapid System premium high performance rapid setting two-part flexible tile mortar for all mortar bond set interior floor paver and wall tile applications and accelerated installation time sensitive applications.
 - 2.5.4.1.2.2 Kerabond/Keralastic System premium high performance two-part flexible tile mortar system for conventional curing time applications for interior floor and wall tiles only
- 2.5.4.1.3 Laticrete:
 - 2.5.4.1.3.1 Laticrete 254 Platinum
- 2.5.5 Metal window sill channels, structural steel angles and other miscellaneous metals elements to receive a bonded tile finish if applicable
 - 2.5.5.1 Mapei
 - 2.5.5.1.1 Primer E high performance 100%-solids epoxy primer with silica sand broadcast until rejection applied to wet primer with Mapelastic 315 applied over sanded Primer E where applicable followed by Granirapid System or Kerabond/Keralastic System to bond tile to metal.
 - 2.5.5.2 Or approved equal
- 2.5.6 Typical Floor & Wall Tile Premium Grout
 - 2.5.6.1 Floor Tile Grout: Cement based chemical-resistant, water-cleanable, tile grout: Conforming to ANSI A118.7. Acceptable Products:
 - 2.5.6.1.1 Custom Building Products: Prism SureColor Grout
 - 2.5.6.1.2 Mapei: UltraColour Plus – Ultra premium fast setting polymer modified non-shrinking sanded grout
 - 2.5.6.1.3 Laticrete: PermaColor Grout

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- 2.5.6.1.4 Colour: To be selected by architect from manufacturers standard colours
 - 2.5.7 Special Case Floor & Wall Tile Epoxy grout
 - 2.5.7.1 Floor tile epoxy grout for use only for special applications if necessary
 - 2.5.7.1.1 Custom Building Products: CEG-Lite 100% Solids Commercial Epoxy Grout
 - 2.5.7.1.2 Laticrete SpectraLock Pro Epoxy Grout
 - 2.5.7.1.3 Colour: To be selected by Architect from manufacturers standard colours
 - 2.5.8 Prefabricated movement joints
 - 2.5.8.1 As per TTMAC, TCNA and manufacturers recommendations
 - 2.5.8.2 Shall be purpose made, having a Shore A hardness of not less than 60 and elasticity of plus or minus 40 percent when used in accordance to TTMAC Detail 301 MJ.
 - 2.5.8.3 Pre-manufactured control and expansion joint products with replaceable gaskets and covers:
 - 2.5.8.3.1 Control Joint Acceptable Examples:
 - 2.5.8.3.1.1 Schluter Systems Dilex KSN surface joint profile with replaceable gasket in height to match floor tile with thin set mortar per manufacturer's recommendations and color to match tile grout
 - 2.5.8.3.1.2 Schluter Systems Dilex BT expansion joint profile in height to match floor tile with thin set mortar per manufacturer's recommendations and color to match tile grout
 - 2.5.8.3.2 Expansion Joint Acceptable Example:
 - 2.5.8.3.2.1 Balco Inc, model SAA-1 : 1" topping slab expansion joint cover
 - 2.5.8.3.3 Wall Termination Joint where coved porcelain tile base not used acceptable example:
 - 2.5.8.3.3.1 Schluter Systems Dilex KSA perimeter joint profile in height to match floor tile with thin set mortar per manufacturer's recommendations and color to match tile grout
 - 2.5.8.3.4 Floor Tile Sealant: Silicone or Urethane sealant, frost proof and flexible. PC to verify compatibility with all tile setting products actually being used on site and make necessary adjustments to sealant products as required of equal quality and meeting all performance criteria.

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- 2.5.8.3.4.1 Laticrete Latasil one component Silicone Sealant used with Latasil 9118 Primer where required for acceptable bonding to porcelain tile and other surfaces in color to match tile grout
 - 2.5.8.3.4.2 Sika: Sikaflex 2C NS EZ Mix TG - primer should not be required for porcelain but if necessary use Sikaflex 205 primer
 - 2.5.8.3.4.3 Surface in contact must be abraded and free of any coatings to ensure proper bond
 - 2.5.8.3.4.4 Prime tile edges to receive sealant with Sikaflex Primer 202 prior to applying sealant
 - 2.5.8.3.4.5 Install appropriate bond breaker below the sealant to prevent bonding to the mortar surface
- 2.5.9 Waterproofing of Showers
- 2.5.9.1 Provide a manufactured shower waterproofing system including wall and floor membranes, flashing, sloping substrates, integral or compatible floor drains and other products and accessories as required to provide a complete waterproofing system for the entire shower assembly such as manufactured by;
 - 2.5.9.1.1 Schluter - Shower System
 - 2.5.9.1.2 Nobel
 - 2.5.9.2 Follow all manufacturers instructions, requirements and recommendations for its installation and compatibility of associated materials used in conjunction with the system.
 - 2.5.9.3 Slope finish shower floors to drain.
 - 2.5.9.4 Extend waterproofing floor and wall base membrane to areas adjacent to the shower if they will be subjected to excess water from the shower areas sloped to a second floor drain to discharge water as required.
- 2.6 ACCESSORY MATERIALS
- 2.6.1 Reinforcing Wire Fabric: Galvanized, welded wire fabric, 50.8 by 50.8 mm (2 by 2 inches) by 1.57 mm (0.062 inch) diameter; comply with ASTM A 185 and ASTM A 82 except for minimum wire size.
 - 2.6.2 Trowelable Underlayment and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.
 - 2.6.3 Temporary Protective Coating: Product formulated to protect exposed surfaces of tile against adherence of mortar and grout and easily removable after grouting is complete:

- 2.6.3.1 Petroleum paraffin wax, fully refined and odourless or
- 2.6.3.2 Grout release in form of manufacturer's proprietary liquid coating specially formulated for use as a temporary protective coating for tile.
- 2.6.4 Metal Edge Transitions and Expansion Joint Strips: Pre-manufactured products specifically designed for tile installations with installation flanges set in bonding mortar with tile at height to match tiles and setting-bed thicknesses, metallic or combination of metal and PVC or neoprene base, designed specifically for floor and wall applications, stainless steel; ASTM A 666, 300 Series exposed-edge material such as manufactured by Schluter Systems.
- 2.6.5 Sealers shall be compatible for use with unglazed tile as recommended and directed by the tile manufacturer for use in wet areas.
 - 2.6.5.1 Grout Sealer: Manufacturer's standard silicone product for sealing grout joints that does not change the colour of grout.
 - 2.6.5.2 Sealers for Porcelain Tiles: Manufacturer's standard penetrating silicone product for sealing tile that does not change the colour of tile meeting or exceeding CAN/CGSB-25.20, Type 1 or 2 as recommended by tile manufacturers for their respective products.
 - 2.6.5.3 Acceptable Manufacturers:
 - 2.6.5.3.1 Aqua Mix
 - 2.6.5.3.2 Customs Building Products
 - 2.6.5.3.3 HMK Stone Care Systems
 - 2.6.5.3.4 Glaze N Seal
 - 2.6.5.3.5 Stonetech
- 2.6.6 Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.
- 2.7 TILE BACKER BOARD
 - 2.7.1 One of the following:
 - 2.7.1.1 Cementitious Backer Board: ANSI A118.9; High Density, cementitious, glass fiber reinforced, 12.7 mm thick.
 - 2.7.1.2 Fiber-Cement Underlayment: ANSI C 1288, 12.7 mm thick.
 - 2.7.1.3 Schluter Kerdi-Board

STRICTLY CONFIDENTIAL

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- 2.8 MIXING MORTARS & GROUTS
- 2.8.1 Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.
- 2.8.2 Add materials, water, and additives in accurate and consistent proportions per manufacturers' written instructions.
- 2.8.3 Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated per manufacturers' written instructions.
- 2.8.4 Scratch Coat (by volume) only if required for existing conditions: 1 part Portland cement, 4 parts sand, and latex additive where required by TTMAC Detail. Premixed mortar may be used per manufacturer's instructions. Adjust water volume depending on moisture content of sand to obtain consistency and workability.
- 2.8.5 Slurry Bond Coat: mix Portland cement and water to a creamy paste consistency. Include latex additive where required by TTMAC Detail.
- 2.8.6 Leveling Coat (by volume) only if required for existing conditions: 1 part Portland cement, 4 parts sand, and latex additive where required by TTMAC Detail. Premixed mortar may be used per manufacturer's instructions.
- 2.8.7 Mortar Bed for Floors: 1 part Portland cement, 4 parts sand, and latex additive where required by TTMAC Detail. Premixed mortar may be used per manufacturer's instructions. Adjust water volume depending on moisture content of sand to obtain consistency and workability.
- 2.8.8 When mixed with water the mortar bed shall be of such a consistency and workability that will allow maximum compaction during tamping of the mortar bed, and achieve a minimum compressive strength of 15 MPa after 28 days. A stronger mix can be achieved by adding latex to the water.

PART 3 - EXECUTION

- 3.1 EXAMINATION
- 3.1.1 Examine substrates, areas, and conditions where tile will be installed, with Installer present. Correct unsatisfactory conditions. Report cracks in excess of 1/16th of an inch in new and existing floor slabs to remain or other potentially adverse conditions to the tile installation or integrity of the building to the Architect and Structural Engineer.
- 3.1.2 Verify all new and existing surfaces have been properly prepared and work conditions Start of work indicates acceptance of conditions.
- 3.1.3 Verify that substrates for setting tile are firm; dimensionally stable; dry; clean; free of oil, sealers, waxy films, and curing compounds; and within flatness tolerances required by referenced ANSI A108 Series of tile installation standards for installations indicated.

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- 3.1.4 Allow all new structural slabs, new structural slabs over existing slabs as well as replacement and repairs of existing structural slabs to cure for a minimum of 28 days (90 days or longer is preferable) prior to installation of the tile assemblies.
 - 3.1.5 Verify that installation of grounds, anchors, recessed frames, recessed Walker ducts and junction boxes, electrical and mechanical units of work, and similar items located in or behind tile have been completed before installing tile.
 - 3.1.6 Verify that all control and expansion joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust joint locations in consultation with the Architect.
 - 3.1.7 Ensure concrete floors have not been treated with curing compounds.
 - 3.1.8 Ensure concrete floors scheduled to receive thin-set applied tile are steel troweled to a fine broom finish. Ensure concrete slabs have been finished with a maximum permissible variation of 6 mm in 3049 mm from the required plane and not more than 2 mm in 305 mm when measured from high points in the surface.
 - 3.1.9 Ensure concrete floors scheduled to receive tile applied over a bonded mortar bed have been screed finished. Verify substrate surface variation does not exceed 6 mm in 3049 mm.
 - 3.1.10 Notify Consultant in writing of unacceptable substrate conditions. Beginning of installation implies acceptance of existing conditions.
 - 3.2 PREPARATION
 - 3.2.1 Remove coatings, including curing compounds and other substances containing soap, wax, oil, or silicone that are incompatible with tile-setting materials.
 - 3.2.2 Blending: For tile exhibiting colour variations within ranges selected during Sample submittals, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colours as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.
 - 3.2.3 Field-Applied Temporary Protective Coating: Where indicated under tile type or needed to prevent grout from staining or adhering to exposed tile surfaces, pre-coat them with continuous film of temporary protective coating, taking care not to coat unexposed tile surfaces. Also provide and maintain protection for tile as required from all foot and equipment traffic throughout installation process until final acceptance of project.
 - 3.2.4 Provide full weather protection for all tiled work areas and maintain temperature ranges specified above during all final preparation of the work areas, during the installation of all tile systems and related components and during all minimum curing times as required by each manufacturer for each product used. This requirement shall apply to new construction as well as repairs, replacement and remodeling of existing tiled surfaces. Provide tarping, tenting and temporary heat as required.
 - 3.2.5 Protect surrounding work from damage or disfiguration.

- 3.2.6 Thoroughly clean existing surfaces that are to receive tile finish to ensure the removal of all grease, oil or dust film.
- 3.2.7 If required apply a latex cementitious levelling coat wherever a slight substrate irregularity exists. Limit leveling coat thickness to less than 8 mm where thin-set tile methods are to be used. A leveling coat in excess of 8 mm shall be set with a mortar bed method.
- 3.2.8 Only where and if applicable for repair of existing floor tile assemblies install cleavage membrane over structural concrete slab. If a cleavage membrane is being applied over a rough surface, apply a 6 mm thick sand-bed under the cleavage membrane.
- 3.2.9 Where finished tile floors are to be flush with adjacent floors, ensure that concrete slabs have been designed to be depressed the thickness of the mortar bed, bond coat and tile.

3.3 CONTROL JOINTS

- 3.3.1 Follow TTMAC Guidelines for Expansion and Control joint details keeping these joints free of setting materials.
- 3.3.2 Provide control joints in tile for each cold joint in slab unless the architect permits crack isolation member in lieu of control joint.
- 3.3.3 Locate control joints in tile where required directly above control joints in substrates or directly above construction cold joints Extend joint through setting material to minimize stress in bond layer.
- 3.3.4 Where new tiles replace or extend existing tiles or unit paving areas, locate control joints to replace and/or extend existing control joints.
- 3.3.5 Install all control joints in tile and setting bed as detailed in the architectural drawings, as specified in the tile installation standards and manufacturers written instructions and as per the following table.

Enviroment	Minimum	Maximum	Joint Width
Interior	4878 mm	6098 mm	6 mm minimum
Interior/Sunlight	2439 mm	3659 mm	6 mm minimum
Exterior - Normal	2439 mm	3659 mm	10 mm minimum
Exterior - Excessive	2439 mm	3049 mm	13 mm minimum

- 3.3.6 All control and expansion joints shall be designed with a continuous waterproof flashing strip installed in a manner to provide a half loop of loose fitting un-adhered material along the entire length of the joint with the remaining edges of the material fully adhered to the respective crack isolation/waterproof membrane on each side of the joint that permits independent movement while maintaining a waterproof joint and membrane layer.
- 3.4 PROVIDE PRE-MANUFACTURED CONTROL AND EXPANSION JOINT PRODUCTS WITH REPLACEABLE EXPANSION STRIPS DESIGNED AND MATCHED TO EACH SPECIFIC APPLICATION, THE TYPE AND AMOUNT OF MOVEMENT TO BE

- EXPECTED AT EACH CONTROL AND EXPANSION JOINT AS WELL AS ALL TRANSITIONS FROM TILED FLOORS TO TILED WALL BASES. SEALANTS WILL NOT BE ACCEPTABLE AS THE PRIMARY MATERIAL FOR FLOOR JOINTS. INSTALLATION
- 3.4.1 ANSI Tile Installation Standards: Comply with parts of ANSI A108 Series "Specifications for Installation of Ceramic Tile" that apply to types of setting and grouting materials and to methods indicated in ceramic tile installation schedules.
- 3.4.2 TCA Installation Guidelines: TCA's "Handbook for Ceramic Tile Installation." Comply with TCA installation methods indicated in ceramic tile installation schedules.
- 3.4.3 Refer to notes on pages 10 – 14 and Detail 301 MJ-2-002 in TTMAC Manual.
- 3.4.4 Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.
- 3.4.5 All tile edges shall terminate into another building element perpendicular to the tile edge or an appropriate tile accessory transition strip. Exposed tile edges are not acceptable. Tile accessory transition strips shall also be used at butted floor transitions so that the accessory strip will form a straight transition to the adjacent material and the tile can start with a grout joint between the transition strip and adjacent material to provide a clean installation, allow for dissimilar movement of materials and protect the tile edges from chipping.
- 3.4.6 Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions, unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.
- 3.4.7 Properly plan all work prior to installing any tile to establish starting points, incorporate existing joint lines of adjacent tiled areas to blend coherently with the new tiled areas, minimize material waste and to provide well executed terminations at walls and other obstructions avoiding substantial areas of small tiles that are unsightly or compromise installation and performance. See Tolerances section below.
- 3.4.8 Design, construct and install all finish flooring material and all transitions to adjacent building elements or changes in material to eliminate tripping hazards at all transitions.
- 3.4.9 Jointing Pattern: Lay tile in grid pattern as shown on drawings unless indicated otherwise. Align joints when adjoining tiles on floor, wall base and trim are same size. Lay out tile work and centre tile fields in both directions in each space or on each wall area unless indicated otherwise. Adjust to minimize tile cutting. Provide uniform joint widths unless indicated otherwise. Layout tile strips over Walker Ducts at fare gate locations to align with existing tile joints as indicated. Provide joint widths to align with existing pavers and joints.
- 3.4.10 Expansion Joints: Locate expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tiles. Locate joints in tile surfaces directly above joints in concrete substrates.

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- 3.4.11 Apply slurry coat to properly cured structural slab followed by the thick mortar bed in a timely fashion to ensure a strong bond of the thick mortar bed to the structural slab.
- 3.4.12 Apply the thick mortar bed in 2 parts by installing the first layer then tamping it down to a thickness equal to the recommended location of the reinforcing mesh. Immediately install the reinforcing mesh followed by the remaining second part of the thick mortar bed in a timely fashion as required to allow the bed to cure as a single uniform bed. Before the mortar bed sets tamp the material again to remove all voids then form and trowel the top surface to the proper specific sub-elevations sloped to drain in all directions to support the membrane and thin-set finish tile finish floor to elevations required for proper drainage.
- 3.4.13 Waterproof and Anti-Fracture combination and individual Membranes: Install the membrane specified for each work area per manufacturers written instructions after minimum mortar bed curing times and site condition requirements have been met as recommended by the membrane manufacturer.
- 3.4.14 Crack Isolation: Use method 309 F from TTMAC Manual or crack isolation membrane where recommended by membrane manufacturer.
- 3.4.15 After minimum membrane curing times and site condition requirements have been met as recommended by the membrane manufacturer, apply mortar bond coat per manufacturer's written instruction to specified thickness and method using the notched trowel recommended for the product and tile setting installation method specified.
- 3.4.16 Metal Edge Strips: Install at locations as required, at exposed edges and where exposed edge of tile meets other finishes prior to the tile being installed per manufacturers written instructions.
- 3.4.17 Prior to installation ensure that the back of each tile is free of contaminants.
- 3.4.18 Apply tile to bond coat while bond coat is wet and tacky before bond coat skins over. Use sufficient bond to ensure 95% contact on surfaces. For tile with raised or textured backs, bonding material must be evenly dispersed and pressed into the back of the tile to ensure a minimum of 95% coverage. Notch bond coat in horizontal straight lines and set on the freshly set bonding material while moving (sliding) tile back and forth at 90° to the notches. Ensure corner and edges are fully supported by bonding material. Set and level tiles with adjacent tiles avoiding lippage.
- 3.4.19 Occasionally check individual tiles to ensure contact and coverage is sufficient and evenly distributed. Do not apply more mortar than tile that can be installed within the recommended mortar working time or working session.
- 3.4.20 Joint Widths - Slide tile firmly into position and set flush with all adjacent tile surfaces with all grout joints evenly spaced and perfectly aligned to achieve joint widths as follows;
- 3.4.20.1 Joint Widths - Porcelain Tile:
- 3.4.20.1.1 Typical Joints: 6 mm
- 3.4.20.1.2 Control Joints: 6 mm

- 3.4.20.2 Joint Widths - Paver Tile: 6.35 mm (1/4 inch typical for new pavers. Joint width for infill strips over Walker Ducts to match existing joint widths.
- 3.4.20.3 Expansion Joints: As required
- 3.4.21 Allow bond coat to cure. Force grout into full depth of joint, remove excess grout, and clean excess bonding material from surface prior to final set.
- 3.4.22 Sound tiles after setting materials have cured and replace hollow sounding tile before grouting.
- 3.4.23 Keep two-thirds of the depth of grout joints free of setting material.
- 3.4.24 Protect exposed edges of floor tile with appropriately sized transition strips. Provide reducer strips where uneven transitions between 6 mm and 12.5 mm occur.
- 3.4.25 Where specified apply penetrating tile sealant to all tile surfaces. Apply 1st coat allowing that to cure then applying a second coat and allowing that to cure before grouting per manufacturer's written instruction.
- 3.4.26 Pre-seal or otherwise protect tiles requiring protection from grout staining
- 3.4.27 After minimum tile setting mortar curing times and site condition requirements have been met grout all tile joints, except expansion or control joints to receive joint sealant, by forcing grout into full depth of joint to ensure dense finish. Tool joint as specified, remove excess grout, retool as required and clean and polish tiles with clean cloths.
- 3.4.28 Grout tile to comply with requirements of the following tile installation standards:
 - 3.4.28.1 For ceramic tile grouts (sand-portland cement; dry-set, commercial portland cement; and latex-portland cement grouts), comply with ANSI A108.10.
 - 3.4.28.2 For chemical-resistant grouts, comply with ANSI A108.6.
- 3.5 TOLERANCES
 - 3.5.1 Tolerances: Observe the following tolerances when laying tiles:
 - 3.5.1.1 Joint variation: not be more than + 1.5 mm except as specified herein.
 - 3.5.1.2 Where tile abuts columns and walls:
 - 3.5.1.2.1 Perimeter tiles: minimum of one-half (1/2) of full-size tile.
 - 3.5.1.2.2 Grout joint: not greater than 6.0 mm wide.
 - 3.5.1.3 Lippage tolerance: 1.0 mm over a 3.0 mm wide joint
 - 3.5.1.4 Tile top surfaces shall be within 1.5 mm of adjacent tiles.

- 3.5.1.5 Tiles shall be installed centered on areas to be covered. Tile joints shall be true to line and square perpendicularly. Joints shall not vary more than 6.0 mm in 6.0 m over their length from establisher layout lines.
- 3.5.1.6 Check completed tile at every column bay for layout conformity.
- 3.6 FIELD QUALITY CONTROL
- 3.6.1 The Work under this Section shall be coordinated with the Work of other Sections to ensure a continuous installation of ceramic wall tiles and related items of Work.
- 3.6.2 All materials shall be field tested to ensure fresh quality for proper, permanent bonds.
- 3.7 CLEANING & PROTECTION
- 3.7.1 PC shall provide appropriate protection during all stages of the tile installation until Substantial Performance Date. Cordon off and/or otherwise protect the tile installation as required preventing any exposure to traffic and adjacent construction activities and allow bond materials to cure meeting the minimum time frame and conditions per manufacturer's written instruction.
- 3.7.2 Where adjacent materials may be adversely affected by tile installation, the PC shall provide suitable protection to prevent damage, discolouration or staining.
- 3.7.3 Protection from freezing during curing shall be provided by the PC as required.
- 3.7.4 Protect work of other trades.
- 3.7.5 Prohibit traffic during installation and for 48 hours after completion.
- 3.7.6 Protect floor from impact and vibration for a minimum of 48 hours after installation. Protect wall base from impact, vibration, heavy hammering on adjacent and opposite walls. On completion of tile floor it is the responsibility of the PC to protect the floor from damage.
- 3.7.7 Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.
- 3.7.8 After tile installation is fully complete and cured provide protective covering in traffic areas until substantial completion of the work
- 3.7.9 Cleaning: On completion of placement and grouting, thoroughly clean tile surfaces so they are free of foreign matter.
- 3.7.10 Remove latex-portland cement grout residue from tile as soon as possible.
- 3.7.11 Thoroughly clean grout smears and hazes from tile according to tile and grout manufacturer's written instructions, but no sooner than 10 days after installation.
- 3.7.12 Use only cleaners recommended by tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of tile and other surfaces to be cleaned.

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- 3.7.13 Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.
- 3.7.14 When recommended by tile manufacturer, apply coat of neutral protective cleaner to completed tile floors and wall base. Protect installed tile work with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear.
- 3.7.15 Before final inspection, remove protective coverings and rinse neutral cleaner from tile surfaces.

END OF SECTION 09310

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SECTION 09962

HIGH PERFORMANCE COATINGS

PART 1 - GENERAL

1.1 WORK INCLUDED

1.2.1 The Work includes the furnishing of all labor, material and equipment required for factory, shop and field application of all special protective coatings and field touch-up of special protective coatings including but not limited to architectural exposed steel, metal fabrications, ornamental handrails and railings and metal doors and frames. Handrails specified as stainless steel are not to be coated.

1.2 RELATED WORK

1.2.2 Section 05120 - Structural Steel

1.2.3 Section 05500 - Metal Fabrications

1.2.4 Section 08110 – Steel Doors and Frames

1.3 QUALITY CONTROL

1.3.1 Coating materials shall be from one supplier only.

1.3.2 The Primary Contractor is responsible for quality control for all aspects of surface preparation and coating application.

1.3.3 The manufacturer of the coating materials shall have produced the coating products for not less than two years, shall be capable of furnishing both products and instructions in their use, and shall have technical personnel and laboratory facilities capable of achieving and testing color match among all items in the Work which will receive protective coatings.

1.3.4 Quality control shall be provided in accordance with the Quality Plan through the Primary Contractor's appointed inspector.

1.3.5 The Primary Contractor shall ensure that the supplier's technical representative is present to review coating procedures during the initial coating application. In addition, the supplier's technical representative shall make periodic inspections of the coating application throughout the remainder of the Work and provide written reports to the Primary Contractor.

1.4 STANDARDS

1.4.1 NACE Industrial Maintenance Painting. National Association of Corrosion Engineers.

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- 1.4.2 SSPC Steel Structures Painting Manual, The Society for Protective Coatings, formerly SSPC - Steel Structures Painting Council.
- 1.4.3 ASTM D5894 Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet).
- 1.4.4 ASTM D522 Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings.
- 1.4.5 ASTM D523, Standard Test Method for Specular Gloss.
- 1.4.6 ASTM D610, Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces.
- 1.4.7 ASTM D660, Standard Test Method for Evaluating Degree of Checking of Exterior Paints.
- 1.4.8 ASTM D661, Standard Test Method for Evaluating Degree of Cracking of Exterior Paints.
- 1.4.9 ASTM D714, Standard Test Method for Evaluating Degree of Blistering of Paints.
- 1.4.10 ASTM D3359, Standard Test Methods for Measuring Adhesion by Tape Test.
- 1.4.11 ASTM D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
- 1.4.12 ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
- 1.4.13 ASTM D4414, Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
- 1.4.14 ASTM D4417, Standard Test Methods for Field Measurement of Surface Profile of BlastCleaned Steel.
- 1.4.15 ASTM D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
- 1.4.16 ASTM D4585, Standard Practice for Testing Water Resistance of Coatings Using Controlled Condensation.
- 1.4.17 ASTM D7091, Standard Practice for Non-destructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals.
- 1.4.18 ISO 2409, Paints and varnishes – Cross-cut test.

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- 1.4.19 ISO 2808, Paints and varnishes – Determination of film thickness.
- 1.4.20 ISO 8503-2, Preparation of steel substrates before application of paints and related products – Surface roughness characteristics of blast-cleaned steel substrates – Part 2: Method for the grading of surface profile of abrasive blast-cleaned steel – Comparator procedure.
- 1.4.21 ISO 9001-2000, Quality management systems – Requirements.
- 1.4.22 ISO 12944, Paints and varnishes – Corrosion protection of steel structures by protective paint systems

1.5 SUBMITTALS

The Primary Contractor will retain reviewed submittals and make them available on request to the Province's Representative. Submittals will include:

- 1.5.1 Product Data: Cross-reference products to coating system and locations of application areas. Use same designations indicated on Drawings and in schedules.
 - 1.5.1.1 Manufacturer's product data sheet
 - 1.5.1.2 MSDS Sheet
 - 1.5.1.3 Performance test data.
 - 1.5.2 Samples for Initial Selection: For each type of finish-coat product indicated.
 - 1.5.3 Samples for Verification: For each type of coating system and in each colour and gloss of finish coat indicated.
 - 1.5.3.1 Submit Samples on rigid backing, 200 mm (8 inches) square.
 - 1.5.3.2 Step coats on Samples to show each coat required for system.
 - 1.5.3.3 Label each coat of each Sample.
 - 1.5.3.4 Label each Sample for location and application area.
 - 1.5.4 Installer/ Applicator Qualifications: pre-qualified by coating manufacturer
- ## 1.6 QUALITY ASSURANCE
- 1.6.1 Inspection Agency/ Quality Control: Provide quality control in accordance with contractor's Quality Management System through an independent NACE Level 1 inspector.

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- 1.6.2 Mock-ups: Apply benchmark samples of each coating system indicated to verify preliminary selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
- 1.6.2.1 Wall and Ceiling Surfaces: Provide samples of at least 9 sq. m.
 - 1.6.2.2 Other Items: Station Architect will designate items or areas required.
 - 1.6.2.3 Apply benchmark samples after permanent lighting and other environmental services have been activated.
 - 1.6.2.4 Final approval of colour selections will be based on benchmark samples.
- 1.6.3 Qualifications – Applicators:
- 1.6.3.1 Applicators shall be skilled, trained, experienced and familiar with the specified requirements and methods necessary for proper performance of work, with a minimum of 3 years experience in projects that are similar in size and complexity.
 - 1.6.3.2 Installer must be pre-qualified by the coating manufacturer as qualified to work with high performance coating materials.
- 1.6.4 Manufacturer’s Representative:
- 2.1.1.1 Ensure manufacturer’s technical representative is present to review coating procedures during the initial coating application. In addition, the supplier’s technical representative shall make periodical inspections of the coating application throughout the remainder of the work and provide written reports on quality control of the results of the inspection.
- 1.7 WARRANTY
- 1.7.1 Provide coating manufacturer’s system manufacturer’s written ten (10) year warranty on coating system installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Subject to compliance with requirements, provide coating system by one of the following manufacturers:
 - 2.1.1.2 International Paint
 - 2.1.1.3 ICI Devoe.
 - 2.1.1.4 Or approved alternative.

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2.2 HIGH-PERFORMANCE COATINGS – GENERAL

2.2.1 Material Compatibility:

2.2.1.1 Provide materials for use within each coating system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.

2.2.1.2 Provide products of same manufacturer for each coat in a coating system.

2.2.2 Colours: As approved by the Station Designer from manufacturer's full range.

2.3 MATERIALS

2.3.1 Total Paint System: Dry Film Thickness: 11 mils minimum.

2.3.1.1 Primer coat - Epoxy Zinc Primer:

2.3.1.1.1 Meet requirements of SSPC Paint 20 Type II.

2.3.1.1.2 Minimum Dry Film Thickness: 3 mils

2.3.1.1.3 Products: Subject to compliance with requirements, provide one of the following:

International Paint; Interzinc 52

ICI High Performance Coatings; Catha-Cote, 313 Organic Zinc.

2.3.1.2 Intermediate Coat - High Build Epoxy Coat:

2.3.1.2.1 Minimum Dry Film Thickness: 6 mils

2.3.1.2.2 Products: Subject to compliance with requirements, provide one of the following:

International Paint; Intergard 475HS

ICI High Performance Coatings; Bar Rust 236 New Technology Epoxy.

2.3.1.3 Polyurethane Finish Coat - Polyurethane, Two-Component, Pigmented, Gloss:

2.3.1.3.1 Minimum Dry Film Thickness: 2 mils

2.3.1.3.2 Products: Subject to compliance with requirements, provide one of the following:

International Paint; Interthane 990

ICI High Performance Coatings; Devthane, 379 (H) UVA. Acrylic Urethane.

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PART 3 - EXECUTION

3.1 EXAMINATION

3.1.1 Substrates to receive coatings must be sound, proper, and free of defects.

3.1.1.1 Surface preparation and coating application facilities shall be inspected by the Filed Engineer and Primary Contractor and meet performance requirements of specification prior to proceeding.

3.1.1.2 Submit to the Primary Contractor, on a daily basis, quality control records detailing the work completed, surface preparation methods, ambient air temperature, relative humidity, structure surface temperature and dew point, coatings used with batch numbers, coating thickness, application method, etc. on inspection sheets as provide by the Primary Contractor.

3.1.1.3 Conditions that would interfere with performance of coating system must be reported to the Primary Contractor and the Filed Engineer in writing and corrected before continuing with specified work.

3.1.2 Examine substrates and conditions, with Applicator present, for compliance with requirements affecting performance of the Work.

3.1.2.1 Inspect substrates before shipment from fabricator's facilities to ensure that steel has been properly prepared to receive abrasive blast cleaning at the coating applicator's facility.

3.1.3 Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.

3.1.4 Begin coating application only after unsatisfactory conditions have been corrected and surfaces are dry.

3.1.5 Coating application indicates acceptance of surfaces and conditions.

3.2 PREPARATION – GENERAL

3.2.1 New Work: Comply with manufacturer's written instructions and recommendations applicable to substrates indicated.

3.2.2 Touch-ups and Repairs: Comply with manufacturer's written instructions and recommendations in applicable to substrates indicated.

3.2.3 Remove plates, machined surfaces, and similar items already in place that are not to be coated. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and coating.

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- 3.2.3.1 After completing coating operations, reinstall items that were removed; use workers skilled in the trades involved.
- 3.2.4 Clean substrates of substances that could impair bond of coatings, including dirt, oil, grease, and incompatible paints and encapsulants.
- 3.3 SURFACE PREPARATION
 - 3.3.1 Cleaning:
 - 3.3.1.1 Use methods recommended in writing by coating manufacturer.
 - 3.3.1.2 Remove rust and loose mill scale. Surfaces must be clean, dry and free from contamination. Prior to paint application, assess and treat surfaces in accordance with ISO 8504. Remove oil and grease in accordance with SSPC-SP1 Solvent Cleaning.
 - 3.3.2 Abrasive Blast Clean: To SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."
 - 3.3.2.1 If oxidation has occurred before coating application, the surface must be re-blasted to the specified standard. Surface defects revealed by the blast cleaning process, should be ground, filled, or treated in the appropriate manner.
 - 3.3.2.2 Surface Profile: 2 - 3 mils (50 - 60 microns).
 - 3.3.3 Stripe Coats: Apply to welds, lap joints, plate edges, corners, sharp edges, and any other areas where spray application of overall coating system may prove difficult resulting in low dry film thickness.
 - 3.3.4 Inspect surface preparation before coating commences. Pictorial Standards (NACE, ASTM, SSPC) or visual standards (NACE) may be used.
 - 3.3.5 Apply coatings prior to flash rusting of steel (8 hours or less) after blasting. If surface has not been coated prior to flash rusting, or 8 hours after abrasive cleaning, re-clean to specified level of blast cleaning.
 - 3.3.6 Field Touch-up and Repairs:
 - 3.3.6.1 Surfaces to be coated should be clean, dry and free from contamination. Prior to paint application, surfaces should be assessed and treated in accordance with ISO 8504, ensuring removal of slag, splatter, dirt, dust, cement, oil, salts and any other surface contamination.
 - 3.3.6.2 Damaged Areas, Welds and Areas of Corrosion: Clean using hand or power tools to a minimum standard of SSPC-SP2 or SSPC-SP3. When using power tools care should be taken to avoid surface polishing.

- 3.3.6.3 Especially on surfaces prepared to SSPC-SP2, brush application will assist surface wetting and improve subsequent coating performance.
- 3.4 APPLICATION – SHOP APPLICATION
 - 3.4.1 Shop apply high-performance coatings according to manufacturer's written instructions.
 - 3.4.1.1 Use applicators and techniques suited for coating and substrate indicated.
 - 3.4.2 If undercoats or other conditions show through final coat, apply additional coats until cured film has a uniform coating finish, colour, and appearance.
 - 3.4.3 Apply coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Produce sharp glass lines and colour breaks.
- 3.5 RESPONSIBILITY FOR TOUCH-UPS AND REPAIRS
 - 3.5.1 Coating Applicator: Damage to steel coatings incurred at coating applicator's facility, and during loading of coated steel to be shipped to Project site.
 - 3.5.2 Steel Fabricator: Damage to steel coatings incurred during shipping from coating application facility to Project site, and unloading at site.
 - 3.5.3 Steel Erector: Damage to steel coatings during storage, handling and erection at Project site.
- 3.6 TOUCH-UPS AND REPAIRS
 - 3.6.1 Primer: High build surface tolerant epoxy.
 - 3.6.1.1 Dry Film Thickness: 4.0 to 7.0 mils
 - 3.6.2 Intermediate: High build surface tolerant epoxy.
 - 3.6.2.1 Dry Film Thickness: 4.0 to 7.0 mils
 - 3.6.3 Finish: Acrylic Polyurethane.
 - 3.6.3.1 Dry Film Thickness: 2.0 to 3.0 mils
 - 3.6.4 Minimum Dry Film Thickness: 11 mils.
- 3.7 REPAIR / RESTORATION
 - 3.7.1 Coats of paint that have peeled off, bubbled, cracked, failed an adhesion test conducted generally in accordance with ASTM D3359 or where visible (rust grade 10 per ASTM D610), shall be considered a failure of the paint system.

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- 3.7.2 Repairs: Clean area back to bare clean substrate, and re-coat with specified coating system as specified.
- 3.7.3 Repairs shall be made at no cost.
- 3.7.4 Repair of Pitted Surface & Weld Seams:
 - 3.7.4.1 Shallow pits less than 3 mm (1/8 inch) deep, shall be filled flush with the plate surface with approved surfacer.
 - 3.7.4.2 Clean pit repaired areas by power disc to SSPC-SP11. After power discing, the surface shall have a roughened profile and definitely not be polished. Feather adjacent coated areas and roughen by power or hand sanding.
 - 3.7.4.3 Welds and weld seams shall be mechanically ground flush, abrasive blast per specification and then stripe coated with specified primer.
- 3.8 RE-INSTALLATION
- 3.8.1 Areas of coating film defects such as skips, inclusion of foreign matter, fish eyes, runs, curtains, gassing, bubbling, or dry spray should be corrected immediately by re-installation of coating system in accordance with manufacturers' instructions.
- 3.9 FIELD QUALITY CONTROL
- 3.9.1 Primary Contractor's Responsibility:
 - 3.9.1.1 Cooperate with the independent inspection agency
 - 3.9.1.2 Witness and certify inspection report
- 3.9.2 Inspection agency's responsibility
 - 3.9.2.1 Establish hold point after surface preparation, and after application of each successive coat of paint. These points shall include but not be limited to the following:
 - 3.9.2.1.1 Pre-Surface Preparation Inspection.
 - 3.9.2.1.2 Measurement of Environmental Conditions.
 - 3.9.2.1.3 Evaluation of Compressor and Surface Preparation Equipment.
 - 3.9.2.1.4 Determination of Surface Preparation Cleanliness and Profile.
 - 3.9.2.1.5 Inspection of Application Equipment.
 - 3.9.2.1.6 Witnessing Coating Mixing.
 - 3.9.2.1.7 Determination of Wet Film Thickness.
 - 3.9.2.1.8 Determination of Dry Film Thickness.
 - 3.9.2.1.9 Evaluating Cleanliness between Coats.
 - 3.9.2.1.10 Adhesion Testing on Spot Basis.

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- 3.9.2.2 Test Reports: Prepare and submit to the Primary Contractor on a daily basis, test reports listing test data required and work completed per this specification. Include documentation of testing procedures indicating:
 - 3.9.2.2.1 Film thickness gage used
 - 3.9.2.2.2 Locations where tests were made
 - 3.9.2.2.3 Dry film thickness at each location
 - 3.9.2.2.4 Name of person performing tests.
 - 3.9.2.3 Contractor shall witness the testing and certify test report.
- 3.10 CLEANING
- 3.10.1 Field Touch-ups and Repairs:
- 3.10.1.1 For work at Project site, prior to Substantial Performance, clean site and make it ready for utilization. At the completion of the work, remove from site tools, appliances, construction equipment and machinery, and surplus materials. Restore to original condition property not designated for alteration by contract documents. This includes, but is not limited to, surfaces inadvertently painted such as glass, masonry, etc.
 - 3.10.1.2 At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
 - 3.10.1.3 After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
 - 3.10.1.4 Protect work of other trades against damage from coating operation. Correct damage by cleaning, repairing, replacing, and recoating, as approved by the Field Engineer, and leave in an undamaged condition.
 - 3.10.1.5 At completion of construction activities of other trades, touch up and restore damaged or defaced coated surfaces.
- 3.11 SHOP AND FIELD QUALITY CONTROL
- 3.11.1 The Province's Representative reserves the right to invoke the following procedure at any time and as often as it deems necessary during the period when coatings are being applied:
- 3.11.1.1 The Primary Contractor will engage the services of a qualified testing agency to sample coating material being used. Samples of material delivered to Project site will be taken, identified, sealed, and certified in presence of the Primary Contractor.
 - 3.11.1.2 Testing agency will perform tests for compliance with specified requirements.

- 3.11.1.3 The Province's Representative may direct the Primary Contractor to stop applying coatings if test results show materials being used do not comply with specified requirements. Remove non-complying coating materials from Project site, pay for testing, and recoat surfaces coated with rejected materials. Primary Contractor will be required to remove rejected materials from previously coated surfaces if, on recoating with complying materials, the two coatings are incompatible.

END OF SECTION 09662

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